Bulletin
of the
Geological Society of America

VOLUME 50 DECEMBER 1, 1939 NUMBER 12, PART 2

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Subscription, $10 per year.
Publication Office: Florida Avenue and Eckington Place, Washington, D. C.
Communications for publication should be addressed to The Geological Society of America, Prof. Charles P. Berkey, Secretary, 419 West 117th Street, New York, N. Y.

NOTICE.—In accordance with the rules established by the Council, claims for non-receipt of the preceding number of the Bulletin must be sent to the Secretary of the Society within three months of the date of the receipt of this number in order to be filled gratis.

Entered as second-class matter in the Post-Office at Washington, D. C., under the Act of Congress of July 16, 1894.

Accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 8, 1918.

PRESS OF JUDD & DETWEILER, INC., WASHINGTON, D. C.

DECEMBER MEETING AT MINNEAPOLIS

EOCENE ANAUXITE CLAYS AND SANDS IN THE COAST RANGE OF CALIFORNIA

BY VICTOR T. ALLEN

Eocene anauxite clays and sands occur at Tesla, 24 miles southeast of Mt. Diablo, and at Brentwood, 14 miles northeast of Mt. Diablo. In places clays and sands with an Ione mineral assemblage are interfingered with biotite sands from another source, in part of Coast Range derivation. On the basis of fossils examined by Bruce L. Clark the Tesla occurrence is assigned to the Capay division and the two horizons at Brentwood to the Meganos D and the Domengine divisions of the Eocene. The type Ione in the Sierra Nevada foothills is now considered Capay. The Capay at its type locality in the Coast Range lacks typical Ione minerals, which are present in the Potrero Hills near Suisun and at a depth of about 4500 feet at Rio Vista, within 35 miles of known Ione sediments to the east at the Clements well. Preliminary results of petrographic, X-ray, and chemical studies suggest that Eocene streams crossed what is now the Great Valley of California and contributed sediments to what is now the Coast Range. (Geological Society project.)

TREASURE MOUNTAIN INTRUSIVE

BY GEORGE W. BAIN

Treasure Mountain is the top of a dome with a northwest-southeast axis in the Elk Mountains of Colorado. A large salic intrusive is exposed at intervals for 3 miles on its northeast flank by four cirques and Crystal River Valley. Another cirque exposes the southeast end. The top and northeast slope of the roof conforms with antecedent sheeted structures. The southwest side drops in a series of "breasts" following joints almost perpendicular to the sheeting. Apophyses of the roof phase, a millimeter or more in thickness, penetrate the sheeting and joint surfaces of the roof. Xenoliths were not found in the intrusive. Flow structures were observed at only one place and for only 20 feet along the contact.

The roof phase of the intrusive is a quartz porphyry about 100 to 150 feet thick on the top and southwest sides; its thickness diminishes to less than 10 feet on the northeast roof slope. This porphyritic phase contains almost all the numerous pegmatites of the intrusive. The pegmatites are surrounded by a narrow aplitic band. A thin aplitic phase below the alaskite is separated from the main granite mass by porphyritic granite. (Geological Society project.)

STRUCTURAL CONTROL IN EUROPEAN LEAD-ZINC ORES OF THE MISSISSIPPI VALLEY TYPE

BY CHARLES H. BEHRE, JR.

This discussion is limited to tectonic, nonmineralogic features, observed during 9 months of field work, supplemented with observations by others.

The flat-lying strata of German and Polish Silesia and those of the north Moroccan deposits (Oujda, Touissit) show ore following bedding partings near normal faults; absence of obvious trunk channels suggests the Upper Mississippi Valley and Tri-State relationships in the United States. The ores near Alston (northern England) and Djalta (Tunisia) are similar. Somewhat similar also are those of Derbyshire (Mill Close mine), but here mineralized fissures are well exposed.

At Aachen and near-by Limburg (Holland) and Moresnet (Belgium) mineralized large faults, from which the ore spread outward, are well marked, and bedding-plane openings are still prominent. In Wales (Halkyn) and the middle Rhine valley (*e.g.*, Ems), however, fault openings play the only important role.

At the opposite extreme from the Silesian deposits are replacements and fissure fillings in Alpine limestones at Mezica (Jugoslavia), Cave di Predil (Italy), and Bleiberg (Austria). These show replacements confined to the neighborhood of complex faults, largely thrusts, yet mineralogy and paragenesis are essentially as in the cases first cited.

Widespread studies yield transition types between (1) deposits in highly strained rocks and (2) deposits in almost undeformed sediments, in which the direction of mineralization is still actively debated, both here and abroad. The tectonic relations of the less deformed types can therefore scarcely be adduced as arguments against hydrothermal origin.

CHEMICAL CHANGES DURING REGIONAL METAMORPHISM IN THE PRESIDENTIAL RANGE OF NEW HAMPSHIRE

BY MARLAND P. BILLINGS

The rocks in the Presidential Range of New Hampshire belong to the Ordovician(?) Ammonoosuc volcanic rocks, the early Devonian Littleton formation, and a late Devonian granite. Regional metamorphism is of the high-grade type. The Littleton formation, which initially consisted of sandstone, shale, and impure dolomite, is now composed of quartzite, mica schist, sillimanite schist, gneiss, actinolite-diopside granulite, and biotite-plagioclase schist.

The structure of the Presidential Range is essentially a doubly plunging synclinorium. There are two schistosities, an older one parallel to the bedding and a later "slip cleavage" parallel to the axial planes of the minor folds.

The chemical composition of the rocks of the Littleton formation has been considerably modified by metasomatic processes. Addition of potash is evidenced almost everywhere by the extensive replacement of andalusite and sillimanite by muscovite and sericite. The lower part of the Littleton formation has been converted into a gneiss by the introduction of soda and lime. Locally this gneiss cannot be distinguished from the typical plutonic rocks. (Geological Society project.)

PROBLEMS OF REGIONAL CORRELATION OF STRUCTURAL ELEMENTS OF WESTERN UNITED STATES

BY PAUL BILLINGSLEY AND AUGUSTUS LOCKE

Regional correlation involves identification and dating of structures within the scattered well-mapped areas and tracing these between areas. This divides into several problems: (1) Evolution of rocks. This is studied in the gradation between rocks of most diverse lithology such as shale-schist-gneiss-granite. This occurs along zones of motion and is maximum at foci of deformation. How common are gradations? Is granite an end product? Does motion cause the recrystallization? (2) Basement control of cover structures. Numerous structures are continuous from cover into basement. Correlative pairs are, for example, monocline over fault. In general, can basement structure be inferred from cover structures? Is basement motion the cause of both? (3) Evolution of structural systems. Some are made by single stage motion never renewed. Many undergo one or more rejuvenations, and others are also complicated by intersecting structure systems. The recrystallization is proportional to the complexity. Eventually the rigidity acquired by recrystallization stops further

motion. How general is this evolution? (4) Correlation of structures with sedimentary formations. Many clastic fans are tied to given structures such as thrust lobes. The fans along a major system, however, are successive rather than contemporaneous and indicate the "firing order" of the uplifts. Often clastic fans are the best clues to structures obliterated by the later deformations in rejuvenated systems.

In conclusion, the writers subdivide the western United States into six north-south panels, each topographically coherent, and indicate the structure systems within each in which the above problems have been particularly studied.

PROGRESSIVE METAMORPHISM OF SILICEOUS LIMESTONE AND DOLOMITE

BY NORMAN L. BOWEN

The metamorphism of siliceous dolomitic limestone is considered with the aid of a composition tetrahedron which suggests that the changes may be referred to 13 steps or grades of increasing decarbonation, taking place at successively higher temperatures at any given pressure. At the temperature appropriate to each step a certain phase assemblage becomes unstable, and each step is characterized by the disappearance of its appropriate phase assemblage. The survival of that phase assemblage in a rock is rigorously indicative of the fact that the step in question has not been attained.

In most of the steps—*e.g.*, 10—the disappearance of its phase assemblage is accompanied by a more conspicuous phenomenon—the appearance of a new phase, a metamorphic mineral—, but this appearance of a new phase cannot be regarded as rigorously indicative of the accomplishment of the step since the new phase can be produced otherwise. Nevertheless if certain additional conditions are fulfilled the new phase will appear only when the temperature of the appropriate step is attained, and the metamorphic minerals then become indicators of grade of metamorphism. In the order of the rising temperature steps at which they are produced the 10 minerals are tremolite, forsterite, diopside, periclase, wollastonite, monticellite, akermanite, spurrite, merwinite, and larnite. Examination of their natural occurrence suggests that they are for the most part produced under conditions which permit their use as temperature indicators.

STRATIGRAPHIC USE OF THE LAMELLIBRANCH GENUS *CONOCARDIUM*

BY CARL C. BRANSON

The little-known genus *Conocardium* contains 232 named species and varieties of which 72 are North American. Many species are inadequately described, and the literature is so scattered that there are no less than 24 homonyms or other invalid names. The range of the genus is from Chazyan to Middle Triassic. The climax of the group with extensive anterior wing is in the Lower and Middle Devonian; of the group with strong siphonal tube the climax is in the Mississippian. Specimens are abundant in many formations, as the Salem of Indiana, the Onondagan limestones of Ohio, Michigan, and New York, the Schoharie grits of New York, and the Graham formation of Texas. *Conocardium* beds are reported from several regions.

The shell bears minute variable details of radial ribs, carination, concentric striae, denticulation of the ventral margin, shape of anterior wing, and character of siphonal tube, so that close distinctions can be made. Characteristic species are found in most American formations from Ordovician to Permian, and these are being used for correlative purposes. The writer is illustrating the types photographically and is establishing the stratigraphic position of described and of new species.

WIND-POLISHED ROCKS IN TRANS-PECOS TEXAS

BY KIRK BRYAN AND CLAUDE C. ALBRITTON, JR.

Polished surfaces attributed to the abrasive action of wind-transported materials occur on massive rocks in parts of the Davis, Finlay, and other mountains of Trans-Pecos Texas. At present the polished surfaces are being destroyed by weathering. This process of destruction seems to have gone on for a considerable time, as on many surfaces the polish is preserved only on scattered patches that have escaped exfoliation. Accordingly the polished surfaces may be interpreted as relics of a time when the Trans-Pecos region was drier than at present.

It is known that streams of the Davis Mountains have alternately filled and channeled their valleys at least three times during the late Quaternary. Previously the writers have suggested that alluviation occurred during relatively humid times and that arroyo cutting progressed during times of relative aridity. It is possible that the formation of wind-polished surfaces in the Davis Mountain area is to be correlated with one of the relatively arid intervals of valley cutting—most likely with the erosion that followed deposition of the Neville formation and preceded deposition of the Calamity formation. (Geological Society project.)

ORIGIN OF THE SUBMARINE MATURE TOPOGRAPHY ON THE CONTINENTAL SLOPE OF EASTERN NORTH AMERICA

BY WALTER H. BUCHER

The mature topography of the continental slopes is so fresh that it is either actively forming now or has been fashioned but "yesterday". Being a surface pattern produced by erosion on a slope formed by deposition, it must owe its origin to a set of circumstances that either appeared anew or at least only after a sufficiently long absence to allow substantial progress of the sedimentation that produced the continental shelf.

Since the submarine slope topography extends to depths far greater than can be accounted for by removal of the water or vertical uplift of the shelf, the force or forces that caused the pattern must lie in the water of the ocean itself—*i.e.*, in "currents". The only "currents" capable of producing effects at right angles to the slope are such as arise on the bottom through wave motion. Only such waves can have an effect on the sea bottom as have wave lengths much greater than the depths at which effects are expected. Two types of such waves are known to oceanographers. Both are observed on the shore; the one as the tide, the other as tsunami.

Recent measurements have proven the existence of currents at great depths of an order of magnitude consistent with tidal theory. They are not strong enough, however, to have eroded the valleys on the continental slope nor can they, as essentially constant forces, be held responsible for what is obviously a new feature.

The tsunami are the shoreward expression of wave motion that originates at the bottom and therefore involves the whole column of water. Their wave lengths—from 20 to 150 km, and even much more—are such that their dynamics are those of waves in shallow water. The energies involved are sufficiently great to permit the conclusion that within a few kilometers of the center of disturbance they permit active erosion on the sea bottom.

The origin of the submarine topography is correspondingly linked to the tectonic and volcanic disturbances that, chiefly since the end of the Tertiary, have been accentuating the suboceanic crustal relief, especially the newer features of the Mid-Atlantic ridge.

Some of the theoretical and practical aspects of this hypothesis will be elaborated.

STRUCTURE AND GENESIS OF THE MOUNT PROSPECT INTRUSIVE COMPLEX, NORTHWESTERN CONNECTICUT

BY EUGENE N. CAMERON*

The principal rocks of the Mount Prospect intrusive complex are massive to markedly foliated granodiorites, quartz diorites, and diorites. Detailed mapping and petrographic study now in progress indicate that these rocks in part are orthomagmatic and in part are due to injection of pre-existing rocks by quartz monzonite, which forms numerous dikes and sills within the area. In addition to quartz monzonite, three other groups of intrusive rocks have invaded the dioritic rocks: (1) A predominantly basic series including diorites, gabbro, norite, hornblendite, pyroxenites, and peridotite, which form dikes and irregular masses; (2) simple and multiple dikes cutting all the above-mentioned rocks; this group (not yet fully investigated) includes quartz diorites, diorites, quartz norite, and hornblendite; and (3) dikes of granite and granite gneiss.

Associated with the first group, which is developed principally on Mount Prospect, are lean nickeliferous pyrrhotite deposits. Rocks of this group show striking similarities to Cortlandt series rocks, but emery is only sparingly present. The members of this group appear to have been intruded in part before and in part after the intrusion of quartz monzonite.

Dikes of group (2) are also developed chiefly on Mount Prospect and appear to be genetically related to the basic series. Dioritic dikes of this group are so numerous as to constitute an important petrogenetic unit. The dikes of group (3) are composed of granite and granite gneiss of the Thomaston type. Pegmatites present in the area may be related to these granitic rocks.

DIASTROPHIC BEHAVIOR AROUND THE BIGHORN BASIN

BY ROLLIN T. CHAMBERLIN

As already stated by others, a striking feature of the mountain belt around the Bighorn Basin is reversal of direction of overthrusting and asymmetry of folding in transverse segments across the ranges. These segments of alternating southwest and northeast thrusting and overturning characterize not only the ranges but are continued in strips of inclined minor anticlines well into or completely across the adjoining basins. Five such strips are recognized. One (with steep flanks facing southwest) reaches from the Powder River Basin across the southern Bighorns, southern Bighorn Basin, Owl Creek Range, northwestern Wind River Basin, Wind River Range, and Gros Ventre Mountains to the very border of the geosynclinal folding which begins in the Hoback Range.

Deformation was that of the Laramide foreland in which the pre-Cambrian rocks and structures, relatively thinly covered, were a determining factor. Strong folding and downdraught at depth in the geosynclinal belt to the west was accompanied by southwestward incrowding of the foreland from the east in the crustal shortening process. The foreland, dominated by the basement complex, deformed in a mosaic of irregular uplifts and basins which were outlined early. In the adjustment to space relations, subunits or transverse strips of these moved differentially. This differential movement continued with slight modification of the strip pattern into the later stages of the orogeny when the minor anticlines developed and became asymmetrical. The axes of these minor folds, however, trend nearly universally northwest-southeast regardless of the trends of the main ranges which were outlined earlier.

* Introduced by S. J. Shand.

GEOLOGY OF THE ALKALINE AND ASSOCIATED INTRUSIVE ROCKS OF BANCROFT, ONTARIO

BY FELIX CHAYES *

The alkaline and associated intrusive rocks of Bancroft lie in a narrow belt along the contact of Laurentian (?) granites on the north with Grenville marble to the south. The rocks form three groups: (1) A nepheline-free syenite-shonkinite series, (2) foyaite, nepheline pegmatite, and carbonatite, and (3) quartz-hastingsite pegmatite.

The syenite-shonkinite series is concentrated in the border zones of the Laurentian granites, occurring only in those portions of the granites most heavily contaminated with amphibolite. All members of the series cut granite, but their relations to included amphibolite are obscure.

Foyaite and nepheline pegmatites are invariably associated with marble which has been intensely deformed and is at present intrusive toward granite, syenite-shonkinite, and amphibolite. This foyaite-carbonatite complex is generally separated from granite by syenite-shonkinite.

Carbonatite is of two types: (1) A coarse white variety which ranges from nearly pure calcite to typical garnet-pyroxene contact marble, and (2) a dark, fine-grained, unsilicated marble indistinguishable from Grenville marble to the south. Almost every outcrop of carbonatite contains both varieties. Both types of marble cut and include granite, syenite-shonkinite, and amphibolite.

Coarse quartz-hastingsite pegmatite is concentrated along contacts of marble with granite and syenite. It cuts all other members of the intrusive series.

The entire complex is separated from the Grenville terrain to the south by a continuous ridge of amphibolite which strikes southeast from Bancroft 8 miles eastward to Egan Chute and there arcs sharply to the northeast.

None of the field evidence is incompatible with the limestone syntexis hypothesis.

GEOLOGY OF AFGHANISTAN

BY FREDERICK G. CLAPP

The paper records, for the use of future investigators, such practical information as has come to the author regarding the geology of Afghanistan, about which little has previously been written except in the broadest reconnaissances. The information should be useful, not only as a basis for future studies in Afghanistan, but also as a link in correlation between America and the Orient.

Some attention is given to the interesting and important physiographic features of Afghanistan. The paper also touches on the tectonics, but these must be left in a passably theoretical stage. The stratigraphic and areal data have advanced considerably beyond previous studies and are here correlated from one part of the country to another and from Afghanistan into Iran and India.

The rocks of the country range in age from early Paleozoic, or even pre-Cambrian, to Recent. The maximum thickness of the composite rock sections may aggregate 60,000 feet, but only a small part of this may exist in any one district. A number of major unconformities exist, of which that at the base of the Cretaceous is one of the most far-reaching. Intensive metamorphism has taken place in the central regions of the country, but the strata of the extreme north have been little disturbed. In the west and south the structure is much cut up by Cretaceous and Tertiary dikes and lava flows.

* Introduced by S. J. Shand.

UNCONFORMITY AT THE BASE OF THE PENNSYLVANIAN HENRIETTA GROUP IN IOWA*

BY L. M. CLINE

In Missouri the lower limit of the Henrietta group is drawn at the base of the Fort Scott limestone, which also marks the lower limit of the Marmaton group in Kansas. The thin but persistent lower limestone member is easily recognized in the field and can be identified in many well sections in northern Missouri and southern Iowa. Whereas the lower Fort Scott may form the most practical base for the Henrietta in Iowa, it does not form the most natural lower limit for this group. After deposition of the Bevier coal and prior to the deposition of the Mulky coal there was a period of uplift followed by the deposition of widespread channel sandstones. Locally, as in Guthrie, Dallas, and Warren counties, Iowa, numerous small faults cut beds of late Cherokee age, and resting on these disturbed strata are sandstone and conglomerate which marks the beginning of Henrietta deposition.

GEOLOGY OF THE CRYSTALLINE ROCKS OF GEORGIA

BY GEOFFREY W. CRICKMAY †

The crystalline rocks of Georgia include northeast-trending belts of metamorphosed sedimentary rocks intruded by igneous rocks some of which are unmetamorphosed. The sediments are represented mainly by biotite gneiss, garnet-mica schist, with some quartzite, marble, and graphite schist. A belt extending northeast from Milledgeville contains slate, quartzite, and pyroclastic rocks. With the possible exception of this last-named belt, all the metamorphosed sedimentary rocks of the State are thought to be pre-Cambrian.

Igneous rocks include old intrusions (probably pre-Cambrian) of granite gneiss, granite augen gneiss, diorite gneiss, and hornblende gneiss, and young intrusions (probably epi-Paleozoic) of granite and Triassic dolerite dikes. In many places occur injection gneiss of mica gneiss and granite, and hornblende gneiss and granite.

The structure is dominated by major thrust faults trending northeast along which bordering rocks have been sheared and locally microgranulated. Schistosity has a general northeast trend with prevailing southeast dip. A reversal of dip to the northwest occurs in places near the Coastal Plain overlap.

MIOCENE FISH FAUNAS OF SOUTHERN CALIFORNIA

BY LORE DAVID AND CHESTER STOCK

Knowledge of the Miocene fishes of California is fragmentary. The best known fauna, from diatomite quarries at Lompoc, Santa Barbara County, contains 52 genera. A fauna from the Modelo formation in Sepulveda Canyon of the Santa Monica Mountains near Los Angeles has furnished 19 genera, 11 identical with Lompoc genera. Excepting rare genera like *Argyropelecus* and *Laytonia*, many forms are restricted to the southern locality, for example *Etringus, Sarda,* and *Scorpaena,* the Caristiidae, and the Scomberesocidae. The Pomatomidae were more abundant in the south. Ecologic conditions or a difference in age may explain these faunal differences rather than temperature changes since the families that show greatest inclination toward a tropical climate—namely the Dussumieridae and the Sparidae—are abundant at the northern locality as well.

In another assemblage, presumably also from the Modelo formation of the Santa Monica Mountains near Van Nuys, deep-sea forms like *Chauliodus, Lampanyctes,*

* Published by permission of the Director of the Iowa Geological Survey.

† Introduced by G. W. Stose.

and a genus related to *Lestidium* are much more abundant than the associated coastal forms *Xyne* and *Syngnathus*. Such a mixture of coastal and bathypelagic genera is not rare in the California Miocene and is common in the Miocene of the Mediterranean.

No special relationship between the Californian and Japanese Miocene fauna is evident. The fish fauna of the Pacific and Atlantic of America were more similar during the Miocene than at present. Many Californian Miocene forms are known today only on the Atlantic Coast, such as the genera related to the living *Alosa* (shad), represented by *Ganolytes* in the California Miocene, *Scomberesox* (the garpike), the bluefishes represented by *Lophar* and *Pseudoseriola*, and a sparid genus related to *Lagodon*. (Geological Society project.)

LOWER AND MIDDLE CAMBRIAN STRATIGRAPHY OF SOUTHWESTERN ALBERTA AND SOUTHEASTERN BRITISH COLUMBIA

BY CHARLES DEISS

The more important unsolved stratigraphic problems in the Waucobian and Albertan rocks of British Columbia in 1938 were: The geographic distribution and variation in thickness of the formations south and west of Ptarmigan and Castle mountains; the origin and relationships of the Ptarmigan limestone to the Cathedral dolomite; the stratigraphic position of the *Albertella* shale on Mounts Bosworth and Assiniboine, and the *Ogygopsis* shale on Mount Stephen; and the extent to which Waucobian formations thin southward against the Montana Island. The Mounts Bosworth and Assiniboine sections were remeasured in 1939. The results are:

On Mount Bosworth the *Albertella* shale is well exposed 385 feet above the Ptarmigan limestone. The Eldon dolomite is 1115 instead of 2728 feet thick. The Lake Louise and Fort Mountain formations do not outcrop, and only 750 instead of 2705 feet of St. Piran is exposed. The total thickness of the Mount Bosworth section is more nearly 6300 than 12,353 feet as originally reported.

The *Ogygopsis* shale seems to rest upon the Cathedral instead of beneath the Eldon on Mount Stephen, thus forming the lower instead of upper part of the Stephen formation. This problem remains unsolved.

The new Gog and Naiset formations are defined for the Waucobian and basal Albertan rocks in the Assiniboine Massif originally assigned respectively to the Fort Mountain Lake Louise and St. Piran, and Mount Whyte formations.

The local Cambrian geography is discussed, and the sections are correlated temporally with those in the Cordilleran area of the United States. (Geological Society project.)

MIDDLE EOCENE FLORA FROM THE VOLCANIC ROCKS OF THE ABSAROKA RANGE, PARK COUNTY, WYOMING

BY ERLING DORF

Collections of fossil plants from the "early basic tuffs" near Valley, Wyoming (Rouse, 1935; 1937), contain about 20 recognizable species of ferns, equisetums, monocotyledons, and dicotyledons. The most abundant species are *Lygodium kaulfussi* Heer, *Acrostichum hesperium* Newberry, *Dryopteris weedii* Knowlton, *Musophyllum complicatum* Lesquereux, *Ficus mississippiensis* (Lesquereux) Berry, *Juglans alkalina* Lesquereux, and *Ficus ungeri* Lesquereux.

On the basis of number of species in common with other floras, there is a close relationship to the floras of the "early basic breccias" of Yellowstone Park, the Aycross (lower Bridger) formation of the southern Absaroka range, and the upper

Green River formation near Green River, Wyoming. In the general facies and the dominance of well-defined species, the flora is distinctly a "Green River flora." The outside distribution of individual species indicates that the flora is of late Green River-early Bridger age, which is considered early Middle Eocene by the writer.

A comparison of the flora with those of the Yellowstone Park volcanic rocks seems to indicate that the plant-bearing beds of the "early basic breccias" are of Middle Eocene age and that the flora of the "early acid breccias" of the Park is Lower Eocene and is not referable to the Paleocene Fort Union, as was previously maintained.

The collections were made by the writer and Dr. John T. Rouse, under the auspices of Princeton University and the Yellowstone-Beartooth-Bighorn Research Association.

PROTEROZOIC PROBLEM IN UTAH

BY A. J. EARDLEY *

New sequences of supposedly Proterozoic strata are described on Promontory Point, Fremont Island, Antelope Island, Sheeprock Range, and the northern Wasatch Mountains. The Big Cottonwood Canyon sequence of Wolcott is emended, and a fragmentary sequence in the west end of the Uintas is given. These and other sections already described are correlated insofar as possible and related to known Cambrian strata overlying them and to the structural features of the region.

The rocks were deposited in deep troughs in and between the northern Utah highland and the Colorado Plateau highland. Each trough was filled with sediments more than 12,000 feet thick. The beds are about half argillaceous and half arenaceous.

The Fremont Island sequence contains a tillite 700 feet thick, and one 1100 feet thick occurs in the Sheeprock Range. Other tillites in the same sections and also in other sections indicate repeated ice advances. The interbedded tillites and associated laminated argillites lead speculatively to the conclusion that the entire sequence of argillaceous, sandy, and tillitic strata may have been laid down during a glacial epoch.

The age of the strata is either lower Cambrian, Proterozoic, or both. Study to date of the degree of metamorphism of Cambrian and underlying strata leads to no definite conclusion. Some deformation and erosion occurred before sands of Lower (?) Cambrian age were deposited, but in light of the highland and trough theory the angular unconformity around the highland margins may not be of great time significance.

LATE TERTIARY ENVIRONMENT IN A PORTION OF THE HIGH PLAINS

BY MAXIM K. ELIAS AND A. L. LUGN

Successive changes in the fossil grassland in Miocene and Pliocene times in western Nebraska and adjacent areas were controlled by minor climatic changes of cyclic nature within a continuous prairie climax.

Evaluation of the sedimentation history reveals environmental conditions essentially identical to conditions indicated by the ecology of the fossil vegetation. Many of the late Tertiary rivers which were largely responsible for the aggradation of the High Plains flowed on low gradients with volumes of water capable of transporting large loads. The interstream areas in each major sedimentation cycle were low, featureless prairies. The genesis of caliche is considered.

The most xeric conditions, similar to the climate of the present "mixed prairie" with *Stipa comata* in the north and *Stipa neomexicana* in the south, existed in

* Introduced by T. S. Lovering.

early Miocene and early Pliocene times, indicated by widespread distribution of *Stipidium* with tuberculate hulls. More mesic conditions are indicated by the appearance of *Stipidium* with smooth hulls, *Berriochloa, Panicum, Setaria,* and certain borages, all common in the Pliocene grasslands, comparable to certain modern grasses and other plants, as the living *Stipa spartea, Oryzopsis, Piptochaetium,* and *Nassella.* Most mesic conditions were attained in late Miocene and late Pliocene times, as indicated by a smooth-hulled *Stipidium* in late Miocene and the disappearance of all Stipeae and dominance of *Panicum* and *Setaria* in late Pliocene.

Local variations in ground-water level and water supply, as well as more general climatic fluctuations, greatly influenced the evolution and migrations of Tertiary faunas.

TELESCOPING IN MARINE CORES

BY K. O. EMERY AND R. S. DIETZ *

In order to obtain long core samples of the ocean floor, a large gravity coring machine was developed for use on the research vessel of the Scripps Institution of Oceanography. Cores up to nearly 12 feet in length were recovered. In using this corer, it was observed that the length of the core was commonly only half to two-thirds of the distance of penetration. The cause of this discrepancy has considerable bearing on correlation between cores and on the determination of rates of deposition of sediments. Small-scale experiments in which colored mud layers were used showed that all layers penetrated were represented in the core but were progressively thinner toward the bottom of the core. This appears to be due to the fact that as the core length increases the force necessary to overcome the wall friction also increases so that, as the core barrel penetrates deeper, more mud is pushed aside and less is added to the core. This same "telescoping" was found in full-scale experiments in which the changing relation between the core length and the distance of penetration was determined by using a high-speed movie camera. Although these experiments show that the core contains samples from the entire length of penetration, factors such as alternation of coarse and fine sediment may produce somewhat different results. (Geological Society project.)

GEOLOGICAL FORMATIONS IN THE VICINITY OF AREQUIPA, PERU

BY C. N. FENNER

During 1939 several months were spent in studying the geology of the Arequipa region.

Three great volcanic mountains lie northwest to northeast of the city: Chachani, El Misti, and Pichu Pichu.

El Misti threw out pumiceous ejecta in the last century, but none have emitted many lavas since the Glacial Period. Lower and intermediate slopes are almost completely covered with thick glacial deposits composed mainly of medium andesites.

In contrast with the andesites are welded siliceous tuffs originating as incandescent sand flows of Katmaian type which filled valleys to depths of hundreds of feet. They are of interest not only for their intrinsic characteristics but because of their important influence on geomorphic developments. Just prior to the Glacial Period they were deeply gashed by streams swollen by increased precipitation that marked the oncoming of glaciation. Voluminous glacial debris brought to the base of the mountains was distributed by torrential streams which filled the gashes and larger

* Introduced by Francis P. Shepard.

valleys with stratified sediments. Subsequently most of these sediments were again removed, and the channels re-established. Under present arid conditions neither erosion nor deposition is prominent. Important fluctuations of temperature and precipitation are indicated.

An exposure of marble near Arequipa contains many rare or new Paleozoic corals not yet identified.

Work upon the various materials is in progress.

LATE QUATERNARY CHANGES OF LEVEL IN WESTERN AND SOUTHERN NEWFOUNDLAND

BY RICHARD FOSTER FLINT

Emerged Quaternary marine features are numerous along the west coast of Newfoundland, although their distribution is patchy. They include wave-cut benches and cliffs, localized constructional forms such as beach ridges, bars, and deltas, and a discontinuous blanket of fossil-bearing marine sediments. These features reach progressively higher elevations as they are followed northward; their positions in long east-west bays indicate a westerly component in the northward rise.

The highest marine limit is very indistinctly recorded, but a lower strand line, cutting the latest glacial deposits, and rising northwestward, is well marked by wave-cut benches on weak rocks. Strand lines in intermediate positions are very weak, but wave-cut benches are well developed at present sea level. These facts indicate upwarping following deglaciation, the movement having been interrupted by one long pause and followed by another pause at present sea level.

No evidence of emergence was found along the western half of the south coast, although emergence may be recorded farther east. The northwestward rise of the marine features along the west coast is consistent with (though it does not prove) the hypothesis that part or all of Newfoundland was invaded by the Labrador ice sheet during the Wisconsin Glacial Age, and that the warping was caused principally by unloading of the crust by this glacier.

Evidence in two districts on the west coast indicates that at least part of the postglacial eustatic rise of sea level occurred while glacier ice was still actively present, and prior to at least part of the crustal warping. (Geological Society project.)

MASHPEE PITTED PLAIN, CAPE COD, MASSACHUSETTS*

BY R. P. GOLDTHWAIT, L. R. THIESMEYER, AND K. F. MATHER

The Mashpee pitted plain slopes southward and eastward in the right angle formed by two belts of moraine on the inner arm of Cape Cod. It was spread as a subaerial fan with a notable concave slope and bedding parallel to the surface. Its material is lithologically like the Buzzards Bay moraine and was derived from the northwest. Very coarse gravel near the apex grades to fine sand along the shore of Vineyard Sound. Kettle holes and associated moraines mark this as a glacio-fluvial deposit. At least 150 feet of gravel was deposited, moraine belts were superposed upon the margins of the plain, subaerial channels were excavated, and ventifacts were formed before the ice blocks melted to produce the kettles.

Clumps of tough gray till are exposed in outwash gravel on the rims of many kettle holes. This unsorted debris must have come from adjacent ice blocks late in the construction of the plain. The bedding surrounding each till clump is contorted.

* Presented with permission of the Director, U. S. Geological Survey.

Channels up to a few hundred feet broad, whose dendritic tributaries and headward gullies indicate subaerial run-off, score the surface of the plain. The channels do not originate in either moraine belt nor do they have the braided pattern of glacio-fluvial drainage. Deep kettles transect some of these stream courses; others occur in the channel floors. No deposits related to the channels occur in the kettle holes. Therefore the ice blocks must have remained until after the sculpturing of the channels.

STRATIGRAPHY, STRUCTURE, AND PETROLOGY OF THE MT. CUBE AREA, NEW HAMPSHIRE

BY JARVIS B. HADLEY *

Studies in the Littleton-Moosilauke area of New Hampshire established the Paleozoic age of a series of metamorphosed sedimentary and volcanic rocks approximately 14,000 feet thick. The oldest formation is the upper Ordovician (?) Albee formation.

In the Mt. Cube quadrangle, lower stratigraphic units are exposed. The lower part of the Albee formation consists in large part of aluminous, carbonaceous schist interbedded with noncarbonaceous quartz-mica schist and quartzite. This overlies the Orfordville formation, which consists of interbedded black schist and volcanic rocks, 5000+ feet thick, also presumably of Ordovician age. The schist represents carbonaceous mud and sand deposited under marine conditions. The volcanic rocks represent metamorphosed basalt flows and tuffs (now amphibolite) with some rhyolite, quartz latite, and dacite (now biotite gneiss). Evidence for submarine extrusion of the volcanic rocks lies in the intimate interbedding with marine deposits, in the absence of any terrestrial deposits associated with the volcanic rocks, and in the presence of pillow structures in the amphibolite.

All the rocks were severely folded, broken by thrust faults, and metamorphosed under conditions of middle-grade metamorphism during the late Devonian. The overturning is toward the east-south-east, except in the southeast part of the area, where it is toward the west. In this region, the structure and metamorphism of the sedimentary rocks have been profoundly influenced by large, syntectonic, concordant instrusive rocks ranging in composition from granite to quartz diorite. Some of these bodies are domical, others sheet-like.

SYNTECTONIC INTRUSION IN NEW HAMPSHIRE

BY JARVIS B. HADLEY †

Intrusion of granitic bodies associated with orogenic zones is said to occur principally after orogenic movements have ceased. Such post-tectonic intrusive rocks are generally described as penetrating the deformed rocks by forcibly pushing them aside or by cutting across them in a manner indicating piecemeal stoping or cauldron subsidence. Foliation and linear elements have been ascribed to independent movements in the crystallizing magma, although Adams and Barlow, H. Cloos, E. Cloos, R. Balk, and M. P. Billings have suggested that such features are also influenced by regional stress.

Evidence that regional stress may have a very important influence on the mechanism of intrusion is found in large bodies of subalkaline rock in western New Hampshire. They are concordant, domical bodies of Devonian age, previously interpreted as pretectonic. In the Mt. Cube quadrangle, two of them

* Introduced by Marland Billings.
† Introduced by Marland Billings.

have profoundly affected the structure and metamorphism of the adjacent sedimentary rocks. The intrusive rocks possess conformable, primary foliation, which appears to have been formed simultaneously with linear elements consisting of flattened and elongated quartz grains, biotite aggregates, and inclusions. These, however, are thoroughly concordant with linear elements related to regional deformation in the surrounding rocks.

Since the primary foliation appears to have been formed simultaneously with linear elements of regional tectonic origin, it follows that the plutonic masses were active during the late Devonian orogenic movements and are, therefore, truly syntectonic. It seems probable also that these bodies were forced into their final positions largely by the orogenic stresses rather than by an ascensive force of their own.

SIGNIFICANCE OF THE DISTRIBUTION OF FOSSILS IN A SERIES OF CORES OF DEEP-SEA SEDIMENT BETWEEN NEWFOUNDLAND AND IRELAND*

BY LLOYD G. HENBEST

The fossil faunas in the 11 deep-sea cores collected by Piggot in 1936 between Newfoundland and Ireland contradict the proposal of extreme changes of sea level as a cause of subaerial erosion of submarine canyons during the time represented by these cores—Pleistocene (at least Wisconsin) and Recent. Only 5 out of 184 samples were barren. The most prolific and taxonomically varied faunas occurred in cores from the shallowest water, and vice versa. Though the benthonic faunas vary in specific composition from zone to zone in each core, they generally have a similar bathymetric facies throughout. No shallow-water or intertidal benthonic faunas were found. The bathymetric facies of each core is characteristic, in general, of the present depth of the ocean at the core locality. According to Tressler, seven of the ostracode species are restricted to deep water; specimens are about evenly distributed among the warm, normal, and cold zones represented in the cores. Pteropod shells are locally abundant in shallowest water and are absent from all cores from the deepest water. Changes of 2000 meters in sea level would have exposed two core stations and reduced the depth of others to the zone of taxonomically more prolific faunas. No evidence for such change was found. Other evidence opposing extreme changes in sea level in Pleistocene and Recent time is that removal of even 2000 meters of ocean water by the mechanisms so far proposed would double salinity and cause extensive migrations of benthonic life. Such changes would exterminate most marine organisms. The history of Miocene to Recent life as read from other sources reveals no such catastrophe.

ETCHING PHENOMENA IN RELATION TO "AMPHISYMMETRY" OF CRYSTALS

BY A. P. HONESS AND H. R. GAULT

Investigations of etch figure phenomena, during recent years, have contributed peculiar and interesting problems relative to the fundamental aspects of crystal structures and comparative rates of solution of various crystal faces. That crystals may be classified by proper interpretation of the etching phenomena obtained by the common inorganic acids is a well-established thesis. However, etch figures produced on the fundamental forms of many crystals by optically active organic solvents do not always permit of the same symmetry interpretation—an apparent

* Published by permission of the Director, U. S. Geological Survey.

disagreement, whose true meaning is not well understood. Suggestions, tending to reconcile the two different types of solution phenomena, are set forth in the Bulletin of the Geological Society of America (May, 1937) with full realization that further experimentation is necessary. In the light of certain trends which were then recognized, laboratory studies have been continued, using such crystals and solvents which might be expected to test tentative conclusions. Etch figures obtained by optically active solvents on calcite were compared with those obtained by the same solvents on such minerals of simple atomic structure as halite, fluorite, and synthetic periclase. Although calcite etchings indicated two different symmetries when optically active and optically inactive solvents were used, the simple cubic minerals gave no evidence of dual symmetry, the full crystallographic symmetry being indicated always, regardless of the nature of the solution. Limited experimentation indicates that "amphisymmetric" etching phenomena may be related to asymmetric atomic groups existing in certain crystalline structures. (Geological Society project.)

TILTED ABANDONED LAKE BEDS IN OHIO

BY GEORGE D. HUBBARD

For 2 summers abandoned lake beds in Ohio have been studied and mapped. A dozen have been examined, and five or six other areas have been studied; no evidence of postglacial lake occupation has been found.

The best evidence of former presence of a lake is in the silts. Occasional traces of shore lines, four deltas, and a few examples of outlet channels have been found.

Tilting is shown by the distribution of the silts. They have been mapped up the slopes as high as they can be found. Erosion is recognized as a modifier of this distribution. In six lake beds the length is great enough to show departure from horizontal distribution. Deltas and outlets identify tilting.

The direction of tilt is consistently nearly southward. The amount of tilting varies from about 2½ feet to 4 feet per mile.

Care has been taken not to mistake moraine and outwash terraces for shore lines. Both are recognized in valleys of central Ohio.

QUATERNARY SANDS ON THE SOUTHERN HIGH PLAINS OF WESTERN TEXAS

BY ROY M. HUFFINGTON AND CLAUDE C. ALBRITTON, JR.*

Quaternary sand dunes cover a large area on the southern High Plains of western Texas, as shown by the 1937 edition of the State geological map. Railway and highway cuts near the station of Sand Hills show that there are two sets of aeolian deposits separated by a disconformity. The older deposit is of relatively compact yellowish and reddish sand. The younger deposit is of incoherent white sand which in places forms active dunes.

It appears that the two bodies of sand record two times of general windiness on the High Plains. As a working hypothesis it is suggested that the older red sands are comparable in age with the reddish cave dust of the Davis Mountains in Trans-Pecos Texas, and therefore that the red sands of the High Plains were deposited during the supposedly arid erosional interval that followed directly on deposition of the Neville formation. Likewise the younger white sands may have accumulated during the erosional stage that followed deposition of the Calamity formation in the Davis Mountain area.

* Introduced by Kirk Bryan.

GLACIAL MARINE WATERS IN SOUTHERN MASSACHUSETTS

BY ESA HYYPPÄ *

Investigations of the diatom content of clay beds at several localities in southern Massachusetts definitely establish the marine character of these clays over a wide area heretofore generally considered to have been occupied by lakes in late glacial time. Since these clays containing marine microfossils at Barrington, Taunton, Middleboro, and Bridgewater are distinctly varved, it appears that the water at these localities was brackish rather than strongly saline. Prior to a final report of the writer's studies of the Cape Cod and Narragansett Bay region the following conclusions may be presented: (1) Clay beds in the Taunton River Valley and parts of Narragansett Bay are marine; (2) This marine stage lies south of the Zero isobase of the marine submergence in the Boston area; and (3) It is evidently not possible for distinctly banded varved clay to form in brackish water.

NEW EVIDENCE FOR THE ILLINOIAN GLACIAL BOUNDARY IN NORTHEASTERN OHIO

BY H. ANDREW IRELAND †

The discovery of undescribed outwash gravel of Illinoian age in the valley of the Tuscarawas River near Port Washington, Ohio, proves that Illinoian ice formerly existed across the headwaters of the present valley north of the Wisconsin boundary. It extends knowledge of the Illinoian boundary for more than 50 miles east of the known Illinoian drift area in central Ohio. The deposit lies 35 miles east of the outwash terrace farthest from the Illinoian drift area. The top of the gravel is 90 feet above the Wisconsin outwash terraces in the same locality, and the deposition was in a bypass of the main Illinoian drainage channel so that it was protected from removal when Wisconsin outflowing water passed along the same main channel. A lower gravel terrace, 30 feet above the Wisconsin terrace, is considered to be of late Illinoian age. Evidence for identifying the high gravels as Illinoian, conditions during that epoch, and a discussion of the related preglacial and Pleistocene physiographic history are presented. The presence of the gravel makes it possible to connect more accurately the drift of the Illinoian Scioto lobe of central Ohio with the Illinoian drift of northwestern Pennsylvania. The existence of the Illinoian ice in northeastern Ohio and northwestern Pennsylvania disproves the statements that drainage of the Upper Ohio basin was northward through the Lake Erie basin.

ROCK GLACIERS IN THE COLORADO FRONT RANGE

BY RONALD L. IVES ‡

Field studies of rock glaciers and similar structures in the Colorado Front Range and adjacent areas disclose that typical rock glaciers are not common but that somewhat atypical talus bodies, having some motion—usually quite slow and probably very irregular—are numerous.

Rock glaciers in all stages of development are present. The lower moraine of Fair Glacier is in transition from moraine to rock glacier, closely resembling similar transition stages reported by Capps. Most of Hitchens' Gulch, in Rocky Mountain National Park, is occupied by a typical rock glacier, fed by "overflow" from the surfaces of talus slopes. A later developmental stage is shown by a large almost

* Introduced by George Otis Smith.
† Introduced by L. G. Westgate.
‡ Introduced by Philip G. Worcester.

static mass of material on the north wall of Hague Creek valley, at the headwaters of the Poudre River.

"Backward" rotation of talus blocks in a "stalled" rock glacier has been noted. The motion of the most active body in this area—the lower moraine of Fair Glacier—appears to be of the order of a few inches a year.

Conclusions from these studies support those of Capps, are in general accord with those summarized by Sharpe, and oppose the rather widespread belief in the rarity of large-scale solifluction phenomena.

DATING ABSAROKA VOLCANIC ROCKS BY VERTEBRATE FOSSILS

BY GLENN L. JEPSEN

Mammalian fossils that aid in dating and correlating volcanic rocks east of Yellowstone Park have been collected at several localities in Park County, Wyoming, under auspices of the Princeton Scott Fund.

One mile north of Merrill Snyder's ranch, on the South Fork of the Shoshone River, teeth that indicate Bridger (Middle Eocene) or Lost Cabin (upper division of the Wind River late Early Eocene) age occur in bedded fine-grained tuffaceous sandstones which Rouse (1935) described and mapped as "early basic tuff" and which are unconformably overlain by his coarse "early basic breccia." One molar is identified as *Microsyops*, a Bridger genus that has close relatives from the Lost Cabin. Another tooth is referred to *Didymictis*, a Torrejon to Lost Cabin genus whose species became progressively larger through the Early Eocene. The specimen is larger than any known Lost Cabin form.

On the North Fork north of Wapiti, 19 miles west of Cody, the "early basic breccia" unconformably overlies sedimentary rocks mapped as "Wasatch" (Geologic Map of Wyoming, 1925). *Homogalax*, diagnostic of Granger's Early Eocene "Gray Bull," was found in coarse buff sandstones near the base of the "Wasatch" section. Higher, in variegated fine-grained sedimentary rocks, a faunule including *Lambdotherium* indicates Lost Cabin age.

These limited identifications suggest (1) That the tuffaceous rocks underlying Rouse's "early basic breccia" in the Snyder ranch area are not older than late Early Eocene and may be of Middle Eocene age, and (2) that the "early basic breccia" near Wapiti is post Lost Cabin.

CALCAREOUS ALGAE AND ALGAL LIMESTONES FROM THE MISSISSIPPIAN OF CENTRAL COLORADO

BY J. HARLAN JOHNSON

The upper portion of the Leadville Limestone (Mississippian) in an area along the west side of the Sawatch Range and extending as far west as Glenwood Springs contains beds which differ greatly from the rest of the formation lithologically. Locally they include oölitic, pisolitic, and chalky beds, or combinations of these.

Studies of thin sections show the presence of Foraminifera in great numbers and an abundance of calcareous algae. Among the latter the genera *Girvanella* and *Mitcheldeania* have been recognized, as well as several hitherto undescribed genera and species. The algae are sufficiently abundant locally to have been the principal builders of the limestone.

The genera *Girvanella* and *Mitcheldeania* occur abundantly in the Mississippian limestones of England, but the genus *Mitcheldeania* has not been recorded hitherto from the American Mississippian.

The lithology, fauna, and flora of these beds suggest that they represent a lagoonal facies.

ECOLOGIC DISTRIBUTION OF LIME-SECRETING ALGAE OF THE PERMIAN CARLSBAD REEF, GUADALUPE MOUNTAINS, NEW MEXICO

BY J. HARLAN JOHNSON

Studies of the reef limestone show calcareous algae in large numbers and considerable variety, and their distribution along and across the reef indicates interesting ecological assemblage.

Along the lower (deeper) slope of the reef front the algae are undescribed forms which consist of masses of fine filaments suggestive of green algae and small nodular masses of very fine entwined twisting tubes or filaments (*Girvanella*) of green or blue-green algae.

The upper slope and crest of the reef front, beside containing the same forms as are found on the lower slope, show a considerable development of red algae belonging to the genus *Solenopora*.

The reef platform or shelf behind the crest shows small colonies of fine filaments (green or blue-green algae) with a few small fragments of *Solenopora*.

In the deposits laid down in the lagoon immediately behind the reef, pisolites containing fine algal filaments, and *Girvanella* nodules occur with abundant Fusulina and other Foraminifera. Associated with the Fusulina, green (siphonous) algae of the genus *Mizzia* are numerous. (Geological Society project.)

OTTAWA-BONNECHERE GRABEN

BY G. MARSHALL KAY

The Ottawa-Bonnechere Graben, in Renfrew County, Ontario, is 35 miles wide. Coulogne Fault, along the Quebec side of the Ottawa River, having a maximum throw of 1000 feet, bounds the structure on the north; on the south, St. Patrick Fault, south of Lake Clear, has similar displacement. Coulogne Fault crosses the Ottawa at Mattawa and continues westward north of Lake Nipissing, the throw decreasing to 200 feet; eastward, it recedes from the Ottawa with decreasing throw; within the graben, en echelon faults of increasing throw are introduced.

Pakenham and Shamrock faults have displacements of a few hundred feet and define a horst south of the Bonnechere. The principal faults north of this horst are downdropped southward, decrease in throw eastward, and limit northward-tilting blocks. Eganville Fault has 400 feet throw, increasing to 700 feet in the en echelon Deacon Fault. Dore Fault, of 600 feet, is joined by the Eganville Fault northwest of Renfrew and terminates west of Arnprior. Muskrat Fault, of similar displacement, meets the Ottawa above the mouth of the Bonnechere and is probably the Carp Fault beyond Lac des Chats.

Block faulting has been described north of the graben. To the south, the Madawaska Highlands, 25 miles wide, has faults paralleling the graben and is margined southward by the scarp of the Plevna Fault, facing the pre-Ordovician peneplane beneath the Lake Ontario Homocline. The faults are believed to be Laramide. (Geological Society project.)

PETROGRAPHIC STUDIES OF THE REX CHERT

BY W. D. KELLER *

The Rex chert member of the Phosphoria formation was studied in thin sections cut from hand specimens collected across the stratigraphic sections at five localities in Idaho, Wyoming, and Utah. The Rex is a fine-grained quartzite with chert in its

* Introduced by E. B. Branson.

upper part in the Big Hole Mountains of Idaho. Southward toward the Utah-Idaho line much of the clastic material disappears, and the member increases to a thick, somewhat calcareous chert series. It decreases in thickness again farther south toward the type locality.

Interesting thin sections were studied in which clastic quartz grains, chalcedony, and microcrystalline quartz, all occurred in one section. Microcrystalline quartz predominates in the chert. The Rex is believed to be a primary, inorganic deposit in the main with some addition by siliceous sponge spicules. The extent to which pene-contemporaneous replacement has occurred cannot be estimated. Subsequent replacement is believed to be insignificant.

CONCENTRIC PATTERNS IN THE GRANITES OF THE LLANO-BURNET REGION, TEXAS

BY DAVID KEPPEL *

The larger bodies of pre-Cambrian coarse-grained granites in the Llano-Burnet uplift of central Texas have been studied with special regard to their structural and textural characteristics. They form steep-walled, roughly circular massifs averaging 12 miles in diameter. Flow structures, best developed near the borders of the massifs, are of the planar variety, principally schlieren or flow layers with occasional schist xenoliths. Lineation within the flow layers was not detected. The flow layers follow the outlines of the massifs and always dip at angles of 70 degrees or more, usually outward from the center. Vertical joints normal to the strike of the flow layers are characteristic of the outer portions of the massifs.

The granite of the massifs exhibits a concentric arrangement of different textural varieties. These are, in order of their solidification, an outer shell of coarse-grained granite, an intermediate zone of porphyritic coarse-grained granite, and an inner core of medium-grained granite. The contacts between adjoining shells of textural varieties are gradational showing that they were all intruded at the same time. Chemical analyses and petrographic examination show that the three textural variations are similar chemically and mineralogically.

Into the concentric pattern, fine-grained granite is intruded in the centers of the massifs, around the margins, and in radially oriented dikes. Pegmatite and aplite dikes near the borders dip inward toward the centers of the massifs, suggesting marginal fissure fillings.

TUNGSTEN ARCS

BY PAUL F. KERR

The tungsten deposits of the Cordillera of the United States define three belts for convenience designated as tungsten arcs: (1) Extending from southern California to eastern Washington; (2) extending from southern Arizona to eastern Idaho; and (3) extending from Silverton, Colorado, to the Black Hills. More important tungsten localities along the arcs are:

Western arc: California: Atolia, Posey, Pine Creek, Tungsten Hills; Nevada: Silver Dyke, Nightingale, Oreana, Mill City; Oregon: Baker-Wallowa Mountain; Washington: Germania.

Central arc: Arizona: Dragoon, Las Guijas, Boriana; Nevada: Snake Range; Idaho: Lemhi.

Eastern arc: Colorado: San Juan, Boulder; South Dakota: Black Hills.

The western arc is perhaps connected with later phases of Nevadian orogeny, the central and perhaps the eastern arcs with Laramide. In each district the min-

* Introduced by Paul F. Kerr.

eralization shows a relationship to the trend of the respective arc and suggests influence of an underlying igneous source.

Deposits are apparently confined to areas of actual or proximate igneous activity. The immediate contact is frequently barren. Aplite and pegmatite dikes or quartz veins favor concentration evidently as conduits from magmatic sources. Conduit bodies frequently contain traces but rarely concentrations of tungsten minerals. Field examination with ultra-violet light evidences the connection between ore formation in a host rock, scheelite-bearing aplitic conduits, and adjacent granitic intrusive rocks.

Considerable deposits may consist chiefly of scheelite, wolframite, hubnerite, or ferberite ores, but the psilomelane or limonite type may prove to be important. Tungsten-bearing minerals occur in hot-spring deposits, in quartz veins, in pegmatite dikes, in greisen zones, and in contact metamorphic deposits. Ca-tungstate predominates in the western arc with the exception of Germania. Ca-, Fe-Mn-, and Mn-tungstates are important in the central arc. Fe-, Mn-, and Fe-Mn-tungstates are most abundant in the eastern arc. (Geological Society project.)

BIRTH OF LOWLAND ICE CAP

BY CHARLES KEYES

The great blizzard of last winter, with its almost unprecedented heavy snowfall, within a narrow belt, that raged across the upper Mississippi Valley from Iowa northeastwardly to Greenland seems to reveal some new possibilities concerning the primal locations of lowland ice caps, early in oncoming glaciations.

During the genial sector of a glacial cycle, when last winter's blizzard occurred, such a severe snowstorm leaves no lasting traces. With an advancing glaciation, however, in the Northern hemisphere and with the southward shifting of the climatic zones, due to the growing excentricity of the earth's orbit, Arctic conditions are imposed at lower and lower latitudes. Some time before maximum stance of glaciation is reached, in the course of 5000 years, or so, such great snowstorms as that just mentioned might readily bank up a drift too large to be dispelled in summer. An ice cap would therefore form.

Should the great snowstorm take place early in the oncoming glaciation and should its path be far to the north, the beginning point of permanent ice formation could be very near the Arctic circle. A Keewatin center would result. If the blizzard chanced to occur late in the 5000-year span, the permanent ice would be situated far to the south, such as a Patrician center, for instance.

Thus, the initial spot of an ice cap is something of a fortuitous situation, both in time and space, during a period of 5000 years, and almost anywhere over the broad, lowland face of a continent.

SNAKE BUTTE BOULDER TRAIN, NORTHERN MONTANA

BY M. M. KNECHTEL *

Glacial striae on shonkinite exposures at Snake Butte, a prominent landmark in the plains south of Harlem, Montana, trend southeastward. A train of shonkinite boulders, many of them huge and some of them striated, extends southeastward 50 miles from Snake Butte across the plains of the Fort Belknap Indian Reservation. The southeastward movement of ice that is indicated is explained as a diversion of the southward-moving Keewatin glacier by the Bearpaw Mountains which stood

* Introduced by Hugh D. Miser.

in its way. The ice west of the Bearpaw Mountains, continuing its southward course unimpeded, formed the Great Falls lobe, described by Calhoun and Alden. The validity of a temporary body of water supposed to have existed south of the Little Rocky Mountains is questioned. The abundant drift in that area, supposed by others to have been ice-rafted, appears to be morainal material.

FLOOD GRAVEL OF SAN GABRIEL CANYON, CALIFORNIA

BY W. C. KRUMBEIN

Fifteen channel samples and six oriented samples were collected from the flood gravel left during the great flood of March 1938, in San Gabriel Canyon, California. The samples extended along 8 miles of the canyon, from above dam No. 1 to near the headwaters. The gravel was analyzed for size, shape, lithology, and fabric. The size showed no appreciable changes; the sorting remained essentially constant; lithology reflected the source rocks adequately; the roundness increased noticeably; sphericity showed little change; the fabric changed from a downstream imbrication near the head of the canyon to typical upstream imbrication farther down.

An important part of the study is the development of a theory of pebble rounding, on the assumption that the rate of rounding is proportional to the difference between the initial roundness and the final roundness-value which is approached by the pebbles in the given environment. This analysis yields a function of the type

$$P=P_0(1-e^{-kx}),$$

where P is the roundness at any point along the stream, P_0 is the final roundness-value approached by the pebbles, k is a constant, and x is the distance along the stream. The observed data agree fairly well with the theory, and earlier experimental work of Wentworth checks the analysis.

PRE-CAMBRIAN CONTROL OF LARAMIDE STRUCTURES IN THE BEARTOOTH RANGE, MONTANA AND WYOMING

BY EDWARD C. H. LAMMERS *

The close coincidence between the pre-Cambrian and Laramide structures in the Beartooth Range indicates a strong control of the latter structures by pre-existing zones of weakness in the basement complex. The borders of the Beartooth Plateau Block, which forms the central and southeastern parts of the present uplift, coincide with the migmatitic border zones of the Beartooth batholith of pre-Cambrian age. Laramide faults in the center of the range follow late pre-Cambrian shatter zones. The plunging nose at the southeast end of the Laramide uplift parallels a similar structure of steeper dip in the pre-Cambrian migmatites. In the area investigated no important Laramide structure was observed that was not closely related to an older structure in the basement complex. (Geological Society project.)

TECTONIC MAP OF THE UNITED STATES

BY CHESTER R. LONGWELL

Tectonic maps, constructed to show the interrelationships of all known major structural features, have great value in the study of the deformation of the crust, provided the maps are reasonably complete and accurate. The making of a satisfactory tectonic map for the United States requires not only the assembling and

* Introduced by Rollin T. Chamberlin.

evaluation of all published structural data but also the contribution of much recent information not yet available in the literature.

The project of preparing such a map of the United States, begun 5 years ago by a committee of the National Research Council, is nearing the final stages. Copy is in preparation for a preliminary edition, which will be offered to geologists for their criticism and additional information. Samples of the preliminary copy indicate the nature of the structural picture that will be presented by the completed map.

THRUST FAULTS OF SOUTHERN NEVADA PHOTOGRAPHED IN COLOR

BY CHESTER R. LONGWELL

Several of the extensive thrusts in southern Nevada have brought dark Paleozoic limestone and dolomite above bright-colored Jurassic sandstone. The Muddy Mountain and Keystone thrusts are excellent examples. Since the bedrock is not concealed by soil or vegetation, the thrust relations are shown strikingly in photographs taken on kodachrome film.

EARLY MARINE STAGE OF THE LAST GLACIATION IN SOUTHERN NEW ENGLAND

BY RICHARD J. LOUGEE *

Investigations of late glacial shore features in the region of Long Island Sound and Narragansett Bay reveal the existence of a former water body with shore lines now submerged along the south side of eastern Long Island Sound and Block Island Sound, and raised above present sea level in the Quinnipiac, lower Connecticut, Thames, and Taunton River valleys, and the Narragansett embayment. A regular system of isobases demonstrates the unity of this widespread water plane which is tilted at a rate of 6-7 feet per mile on its north side.

The sea floor south of the shoal ground between Block Island and Montauk Point has the shape of a delta with gently southward sloping surface and lobate distal border terminating at a depth of 140 feet. This appears to be a marine delta built contemporaneously with the terminal moraine. Shore lines formed when ice recession from the moraine uncovered the Sound, if extended southward, coincide with the level of the submerged delta, thus implying their continuity with marine waters beyond Block Island. Eastward the water plane extends from the Taunton River basin to Plymouth, indicating a marine connection in that direction and a temporary insular condition of Cape Cod.

A new term—the Dana Marine Stage—is suggested for this early marine water because its isobases are independent of those north of Boston, and regional uplift had caused abandonment and tilting of these shores before the uncovering of the Boston region.

WISCONSIN GLACIATION OF NEWFOUNDLAND

BY PAUL MAC CLINTOCK AND W. H. TWENHOFEL

From the presence of fresh erratic stones and ice-scoured topography it is concluded that Newfoundland was completely glaciated during the Wisconsin stage of the Pleistocene. The glaciation had three recognizable episodes: (1) The maximum episode; (2) the Bay St. George episode; and (3) the cirque-forming and local moraine episode. During the first of these ice spread as a complete cap from the Long Range Plateau, the Central Plateau, and the Avalon Peninsula outward in all directions to beyond the present shore lines of the island. It overrode the Anguille and the Bay of Islands Mountains. It rounded the uplands and gouged out the fiords. During the second episode the ice receded, and fossiliferous marine sedi-

* Introduced by George Otis Smith.

ments were deposited. These marine sediments were in several places overridden during a readvance of the ice which in the Bay St. George area deposited a fairly stout and continuous moraine. During the third episode the ice had dwindled to local glaciers excavating cirques at the heads of valleys and building minor moraines such as those at South Branch and Kitty's Brook. The land has subsequently risen so that the marine sediments are well above sea level. (Geological Society project.)

GLACIAL MORAINES OF WESTERN CAPE COD, MASSACHUSETTS*

BY KIRTLEY F. MATHER, RICHARD P. GOLDTHWAIT, LINCOLN R. THIESMEYER

This and the two associated papers by the same authors to be presented in turn by Mr. Goldthwait and Mr. Thiesmeyer are preliminary reports of field investigations in the western part of Cape Cod begun in June 1939, under the auspices of the United States Geological Survey as a part of the cooperative geological research in Massachusetts financed jointly by the Commonwealth and the Federal Government. Recently completed topographic maps, with scale of 2 inches to the mile, were used as a base for the detailed geologic mapping which has been extended over most of the area covered by the Sagamore, Sandwich, Pocasset, Falmouth, and Woods Hole quadrangles.

The most notable features in this area are the Buzzards Bay moraine, extending southwestward along the southeast shore of Buzzards Bay, the Sandwich moraine extending eastward parallel to the south shore of Cape Cod Bay, and the pitted plain east of the former and south of the latter moraine. North of Buzzards Bay is the Ellisville moraine and along the shore north of the Sandwich moraine there are discontinuous remnants of the Scorton moraine, much of which has been destroyed by recent wave action.

These are "push moraines" deposited during minor readvances of two lobes of the Wisconsin ice during its recessional stages in middle or late Wisconsin time. The precise dating within the Wisconsin stages is still under investigation. The lithology of the transported stones reveals the direction from which the ice advanced and is distinctive for two ice lobes.

GEOGRAPHIC CLASSIFICATION OF ANALYSES OF IGNEOUS AND METAMORPHIC ROCKS

BY EDWARD B. MATHEWS

The ambitious undertaking supported by grants from the Geological Society is now well advanced, and it has been deemed advantageous to present to the Fellows of the Society something of the manner of procedure and the results obtained and how the results may be serviceable even before the undertaking is completed.

One of the largest published collections of chemical analyses of rocks is that in Professional Paper 99 which carried analyses published before 1913. This contains over 9000 analyses. The present collection which is to be carried to 1940 already contains between 30,000 and 40,000 analyses grouped in single degree units. Since the sources are indicated this work may well serve as a series of bibliographies of small geographical units, and a geologist going into a new region may readily secure a clue to practically all the available literature sufficiently detailed to have analyses of rocks.

The method of classification, some of the difficulties encountered in securing the location of the samples analyzed, and some suggested improvements which can be made by authors in the future will be discussed if time permits. (Geological Society project.)

* Presented with the permission of the Director of the U. S. Geological Survey.

DEFORMATION IN THE SIERRA NEVADA, CALIFORNIA

BY EVANS B. MAYO

The oldest records of deformation are in the metamorphic rocks. These records include isoclinal folds, cleavage, linear stretching, and flowage structures. In the intrusions, the oldest record is conformable planar and linear parallelism followed by disconformable schlieren and by various dikes and barren fractures.

The metamorphic rocks form a skeleton of the regional structure; intrusions fill in this skeleton. All important directions in the primary framework are paralleled by steep regional joints. Tertiary-Pleistocene faults are closely related to the regional pattern.

The primary movement involved uplift, transverse thrusting, and horizontal shift. Tertiary-Pleistocene movement clearly involved uplift and may have included shift and thrusting.

Intrusions, growing partly by granitization, reached maximum development on intersections of primary structures. Groups of Pleistocene volcanoes are on similar intersections of rejuvenated structures. (Geological Society project.)

CRITICAL EVALUATION OF THE PRESENT STATUS OF THE HELIUM METHOD OF THE AGE DETERMINATION OF ROCKS

BY W. J. MEAD, R. D. EVANS, AND C. GOODMAN

The ratio of helium to radioactivity affords an atomic clock for determining the age of igneous rocks. Reading these radioactive clocks is the responsibility of the physicist and chemist. Evaluation of the time data so obtained is clearly the responsibility of the geologist. Unfortunately, the geologist's acceptance or rejection of such age determinations has been largely a matter of belief or disbelief, rather than judgment based on a critical evaluation of the following geological assumptions involved: (1) Absence of primary helium originally, (2) No introduction of helium subsequently, (3) No escape of helium. It is further assumed that the rate of helium evolution has been constant or has varied at a known rate, and that the analytical observations are reliable.

The recent invalidation of certain helium ages was the result of unreliable measurements. The intercalibrations which revealed these discrepancies have shown the analytical techniques to be capable of a high degree of accuracy and reliability. The rate of evolution of helium from the naturally occurring radioactive elements is well established. The three geological assumptions are still uncertain: (1) is questionable and difficult to appraise; (2) involves the possibility of sources and diffusibility of the gas through rocks; and (3) requires systematic investigations of the helium in individual igneous rock masses and their separate mineral components. The paper summarizes present knowledge, including recent researches. Despite present limitations the helium method is potentially too useful to geology to be ruthlessly discarded without further attempts to make it acceptably reliable. Clearly, future advancement demands close co-operation between geologists and physicists in a mutual attack on these problems.

NEW TERMS FOR LEE DUNES

BY F. A. MELTON

The following new terms are proposed for lee dunes:

1. *Wind-shadow dunes* (umbracer). These are accumulations downwind from an obstacle. Smallest examples are the shrub-coppice dunes which develop in and leeward from clumps of mesquite and other plants in the southern High Plains and

elsewhere. Largest known examples are the longitudinal (old term) dunes of certain plateau margins eroded by winds of nearly constant direction. In this case a headland between re-entrant canyons is the obstacle behind which a dune develops. Known dunes exceed 2 miles in length.

2. *Source-bordering dunes* (lee-source or umbrafon). This type of lee dune develops leeward from a source of supply. The site of deposition has no relationship to the presence of an obstacle. Many examples are found leeward from river flood plains in the Great Plains, leeward from sandy lake beaches, but especially leeward from the westward-facing ocean beaches of temperate latitudes. On such ocean beaches they may become large and form complicated blowout topography.

The term fore-dune which has been in use for some time seems out of place in a genetic classification since it does not place emphasis clearly upon the origin of source-bordering dunes but rather upon their subsequent history.

Field work underlying this classification of lee dunes was performed with the help of the Section of Climatic and Physiographic Research of the United States Soil Conservation Service.

PAWHUSKA ROCK PLAIN OF OKLAHOMA AND KANSAS

BY F. A. MELTON AND W. E. HAM

Linear profiles reveal a relatively smooth and uniform hill-top erosional surface (the Pawhuska rock plain) in the Kansas-Oklahoma Osage Plains. It has very little regional slope, and the elevation approximates 1000 feet. It bevels Carboniferous strata, both hard and soft, of the "Prairie Plains" homocline. Even large cuesta summits show the Pawhuska facet. It also truncates old Paleozoic rocks of the Arbuckle Mountains.

Outstanding characteristics are: (1) Smoothness and gently undulating character, with a general lack of monadnocks, (2) close association with large rivers such as the Arkansas and Canadian, (3) presence of embayments extending westward up these and other rivers, (4) modified escarpments facing the main streams and developed upon different types and ages of rock, regardless of structure (one of the best examples being the east base of the Flint Hills northward from Pawhuska, Oklahoma). The surface extends northward to the Arkansas-Missouri drainage divide in Kansas.

Truncation by the Gerty sands (mid?-Pleistocene Canadian River terrace) suggests early Pleistocene age, as do other relationships.

Lateral swinging of large streams will apparently account for existing relationships —especially the stream-facing escarpments—better than other theories. Possibly Kansan melt water contributed to the erosion by overflowing the low Missouri-Arkansas divide in eastern Kansas. Subaerial weathering could hardly produce escarpments of this type without lithologic or structural control.

The original slopes of the master stream (Arkansas River) and the eroded surface were probably steeper than the present slope of the Pawhuska rock plain, indicating possible Pleistocene, gentle uplift of the Ozark and/or Ouachita areas.

STRUCTURAL GEOLOGY OF THE FELSITES OF IRON MOUNTAIN, MISSOURI*

BY CHARLES MEYER AND CARL TOLMAN

The pre-Cambrian felsite complex, into which the iron deposits of Iron Mountain were introduced, may be differentiated into three major extrusive groups: A lower group of red to gray, quartz-free and usually aphanitic felsites, a thick dominantly

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purple series of lava flows and agglomeratic to tuffaceous pyroclastic rocks, and an upper group of reddish porphyritic to aphanitic lavas.

Though some of these rocks bear distinctive planar flow features and primary fractures, only rarely is even a statistically recognizable orderliness of orientation present, probably because of the inherent acidity of the lavas themselves and the rapidity and violence of their extrusion.

Secondary structural features, however, are very systematically developed. Statistical, three-dimensional representation of the strike and dip of the joints by means of the equal-area projection revealed the presence of 2 groups of low-angle joints in addition to the vertical systems previously described in this and neighboring regions.

CRYSTALLINE ROCKS OF SOUTHERN CALIFORNIA

BY WILLIAM J. MILLER

For nearly 16 years the writer has been engaged in a study of the crystalline rocks widely exposed throughout 40,000 square miles of southern California. Nearly every important part of the region has been visited. Detailed geologic maps of four key areas, comprising more than 1000 square miles, have been published. Many other important areas have also been mapped in detail.

The oldest rocks, believed to be early pre-Cambrian, are, in order of age, metasediments, diorite and metadiorite, granite, mixed rocks (banded gneisses, migmatites, and so on), and anorthosite. With the exception of the anorthosite, these rocks are widely distributed. Distinctly later pre-Cambrian rocks include metasediments (sericite schist, and so on). The Paleozoic includes Cambrian and late Paleozoic (Mississippian?) strata, usually more or less metamorphosed. With one exception, none of these occur south of the San Andreas fault. Triassic metasediments are known only south of the San Andreas fault. Late Jurassic (?) diorite and late Jurassic-early Cretaceous granodiorite and quartz monzonite are widely scattered throughout the region. Still later are Cenozoic sediments and volcanics.

The nature, distribution, origin, ages, relationships, emplacement, and correlation of the crystalline rocks are the writer's principal concern. Particular attention has been given to the problems of origin, and emplacement of the migmatites, banded gneisses, and anorthosite. Fossils found in the metasediments have led to certain rather definite correlations.

Twenty-seven chemical analyses of typical igneous rocks, representing important localities throughout the region, have been made.

ORIGIN OF DEEP POOLS IN THE CHANNEL OF TENNESSEE RIVER

BY BERLEN C. MONEYMAKER AND PORTLAND P. FOX *

The channel of the Tennessee River consists of an alternating series of pools and bedrock shoals (or "bars"). Between Knoxville, Tennessee, and Guntersville, Alabama, this feature of the river is particularly striking. A study of that section of the river reveals the following conditions: (1) In general, the pools occur in relatively narrow stretches of the river, especially in bends, and the shoals occur where the river is somewhat wider and relatively straight. (2) The pools are considerably longer than the shoals, exceeding them by about 50 per cent, and the deepest one known is about 100 feet lower than the shoal which limits it downstream. (3) The pools are, without exception, in soluble rocks (limestone and dolomite), and the shoals are in insoluble rocks (sandstone, cherty limestone, and shale).

* Introduced by Edwin C. Eckel.

Although most of the pools are in bends where high velocities prevail, the rocks are, in many cases, as resistant to abrasion as those forming the shoals, or even more so. The scouring action of the river is undoubtedly an important factor in the development and maintenance of pools, but solution seems to be equally important. This view is supported by deep core drilling at numerous localities on the upper Tennessee River which reveals that limestones and dolomites are cavernous to depths as great as 100 feet below the river channel.

CARBONIFEROUS-PERMIAN BOUNDARY

BY RAYMOND C. MOORE

Requisites of a systematic classification that is practically most useful in all parts of the world include substantial agreement among geologists in acceptance of designated major divisions and of the nomenclature applied to these divisions. Likewise, greatest possible uniformity of usage in definition of systemic boundaries is obviously desirable.

The Carboniferous and Permian systems, respectively understood to include post-Devonian and pre-Permian and post-Carboniferous pre-Triassic rocks, are considered to be among major divisions that should be recognized generally. Agreement in precise definition of the Carboniferous-Permian boundary, both in the type areas and elsewhere, offers difficulties. This paper undertakes to clarify principles that apply to solution of this boundary problem, considers divergent previous usage and present views, and states conclusions that seem likely to aid in reaching general agreement.

The lower boundary of the Permian, as now placed in most sections of North America and western Europe, appears to be stratigraphically below the position of this boundary in the type Russian section. Revision of the Carboniferous-Permian boundary in Russia, as advocated by Ruženčev, Nalivkin, Dunbar, and others, removes evident inconsistencies that otherwise exist, and this change makes classification accord best with paleontologic and stratigraphic relationships in different parts of the world. Acceptance of this revision and of definition of this boundary that recognizes the Wolfcamp and equivalent rocks of North America as lowermost Permian is recommended.

GEOMORPHOLOGY OF MOUNT ABU, INDIA

BY FREDERICK K. MORRIS

Mount Abu is an inselberg, rising from a broad erosion plane in southern Rajputana. It is cut by steep-sided, V-shaped valleys which, at the upland, head abruptly in a broad, gently rolling basin-like area, interpreted as the remnant of a peneplane which cannot be older than Mid-Tertiary and is clearly not the pre-Lameta peneplane of late Cretaceous age on which the Deccan lavas rest. The upland surface includes hills rising moderately above its basin floor, terrace remnants of an ancient valley, and tank-like hollows due largely to the granite's tendency to exfoliate and disintegrate. The side valleys which meet the upland at a geomorphic unconformity are young only because they have steep gradient on the resistant inselberg. Their antiquity is better indicated by the broad lowland valleys to which they are tributary and which are interpreted as part of a late Tertiary bevelling. The writer infers that the hill is part of a maturely dissected Tertiary uplift, lying between the gently basined Deccan plateau of Eocene lavas and the more deeply warped Pleistocene basin of the Indo-Gangetic geosyncline. In the sense that the rocks of Mt. Abu record a pre-Cambrian orogeny, the mountain may be considered part of a pre-Cambrian range; in the topographic sense, however, it cannot be so considered, for the region has been pene-

planed a number of times since the orogeny recorded in the ancient gneisses. The fact that the lowland rivers are fairly adjusted to the structure indicates a tendency for ancient lineaments to repeat themselves in later uplifts and for subsequent rivers to etch out ancient weaknesses.

GRANITE WINDOW OF ASWAN

BY FREDERICK K. MORRIS

Rimmed by bluffs of Nubian sandstone, the gently arched erosion surface of underlying granite is exposed, forming a window, over which the superimposed Nile cascades at Aswan, Egypt. The desert exposures enabled the writer to trace a series of related outcrops evidencing progressive paragenesis of the granite. The oldest rocks are dark easterly dipping schists, largely derived from bedded sediments, but probably in part ancient tuffs. Schistosity is essentially parallel to original bedding. A series of intergrades traced to ancient granite quarries showed progressive recrystallization with coarsening texture and increasing alteration of hornblende to biotite, and the progressive introduction of feldspar and quartz, replacing earlier biotite and hornblende. As most of the feldspars are unoriented, the gneissoid structure inherited from the schist is progressively diminished until the rock is massive granite.

Xenoliths of schist, and of gneiss derived therefrom through partial replacement of micas and hornblendes by blocky feldspar or (and) quartz, are fairly abundant. They retain the strike and dip of the parent schist and are interpreted not as stoped blocks, but as incompletely replaced and reorganized remnants.

The batholith, here at least, was never wholly molten at any one time but represents a minutely fractional replacement of the schist, by uprising impregnating solutions. Differentiated masses were also observed and were interpreted as crystallization products of liquid magma encroaching upon the replacement granites.

PACIFIC OCEAN BASIN

BY FREDERICK K. MORRIS

Because the orogeny that uplifted the Pacific arcs dates from mid-Tertiary or later, the writer infers that the Pacific basin attained its present configuration during Tertiary time. Deeps that lie parallel to arcuate mountains are cognate with them. Theories which propose a mechanical origin of arcs—by underthrusting landward, by overthrusting seaward, or by deep wrinkling of the crust—require that the sediments be driven laterally and heaped into arcuate overturned folds consisting of whatever materials became involved in the thrust, rather than of thick sediments slowly accumulated in geosynclines upon the site of future mountains. Chance would determine whether near-shore or abyssal deposits composed the arcs, and the curvature would depend upon the strength of the thrust. Certain facts are in discord with these inferences. Pacific arcs contain Cretaceous or even Paleozoic rocks. Vast thicknesses and predominance of shallow-water sediments imply geosynclinal conditions. Unconformities mark several foldings followed by renewed deposition. Notable overthrusts are recorded, but none which could remotely account for the arcuate shape. The writer infers that the sediments were deposited in arc-shaped geosynclines approximately where they now lie, although possibly orogenic compression has increased the curvature. Continental islands separated from Australia by deep seas suggest foundering of a once-continuous continent. The writer conceives the mechanism of foundering as including the encroachment of basaltic batholiths beneath lands in or near the Pacific, and replacement of sialic by basic minerals, causing blocks to sink as they attain the density of gabbro.

MECHANISM OF PLASTIC DEFORMATION AND CREEP OF SOLIDS

BY A. NADAI*

The mechanical conditions under which solids can be deformed permanently without fracture are of widespread interest. The ductile metals are used in construction not only because of their high strength but because of their property, when being stressed, of undergoing considerable permanent distortion before fracturing. The conditions under which they flow at atmospheric temperatures have recently been investigated by engineers and metallurgists. The plastic states of stress are frequently accompanied by the formation of fine markings in regular pattern on the surface of the test pieces. These fine markings are the traces of thin layers in which the metal has been deformed locally. The description and geometry of these surfaces of slip have opened up new theoretical approaches to a mechanics of the plastic states of stress in solids.

Distortion due to plastic deformation of rocks is one of the fundamental problems of geology. The conditions prevailing at depth such as small differences in stress, elevated temperature, and high average pressure favor plastic flow. It is noteworthy that the formation of the slip surfaces in small-scale engineering laboratory experiments seems to correspond to phenomena such as faults and discontinuous distortion.

The mechanical laws which are helpful in describing the flow of metals are of interest to geologists. Observations on metals scattered in technical publications as well as others not heretofore reported are presented. Work on extremely slow permanent deformation or creep of metals at elevated temperature under prolonged load has shown that the strongest alloy steels creep indefinitely when temperatures are sufficiently high. Recent observations on creep are included in the paper.

SERPENTINE INTRUSIONS IN RELATION TO THE EVOLUTION OF THE LATE PALEOZOIC OROGEN OF NEW SOUTH WALES

BY GEORGE D. OSBORNE †

The interesting contributions by H. H. Hess to the study of major orogenic belts of the world followed the announcement of important discoveries by Vening Meinesz concerning the distribution of gravity anomalies and the publication of the results of experiments made by Kuenen.

Hess has traced the evolution of an orogen under the concept of his theory. Prominent among the geological events in the deformed zone is the injection of ultramafic magma in belts or zones generally marginal to the geotectoclinal region. No serpentine intrusions are generated during the second downwarping, although late in the tectonic history granitic batholiths may be intruded.

The extensive serpentine belts of northeastern New South Wales have formed part of the writer's investigations upon the structural history of the Hunter-Manning-New England region of New South Wales. The serpentines were injected generally along thrust planes situated on the margins of the folded tract, while granitic batholiths invaded the central parts of the late Paleozoic orogen, during a distinctly later phase of the diastrophism.

In the present paper, the tectonic evolution of the orogenic belt is investigated with the objects of (1) Extending the foundational studies of W. N. Benson upon the problem, and (2) testing the validity of Hess' concepts as applied to a large and important orogen of approximately Appalachian age.

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* Introduced by M. King Hubbert.

† Introduced by Marland P. Billings.

Difficulties arise when one endeavors to fit the theory to data gathered from long field experience in Australia, and it is apparent that certain modifications are necessary in respect to its application to the Hunter-Manning district.

STRUCTURE AND ORIGIN OF THE DEER CREEK VOLCANIC ROCKS, MONTANA

BY WILLARD H. PARSONS*

In southwestern Montana north of the Beartooth Mountain uplift and between the north-flowing Boulder and Stillwater rivers is an area of late Cretaceous volcanic rocks previously included in the Livingston formation but here considered a separate unit. Andesitic volcanic breccias and a few local flows occur along the Deer Creeks surrounded by andesitic volcanic conglomerates and sandstones eastward along the Stillwater River, northward into the Yellowstone River valley, and westward past the Boulder River. These pyroclastics were ejected from many small volcanoes and were carried by streams to the east, north, and west where they are interbedded with upper Cretaceous sediments. The volcanic breccia beds along the Beartooth Mountain front have steep to vertical dips conformable with the deformed Mesozoic and Paleozoic sediments. There extrusive rocks were present before the uplift. An angular unconformity within the volcanic series indicates further eruption after the uplift. (Geological Society project.)

GEOLOGIC MAP OF GEORGIA

BY GARLAND PEYTON †

Announcement is made of the publication of a geologic map of Georgia prepared by the State Division of Mines, Mining, and Geology in co-operation with the United States Geological Survey. The map commemorates the fiftieth anniversary of the founding of the present State Survey.

Authors of the map are C. Wythe Cooke—Coastal Plain; Charles Butts—Paleozoic rocks of the Valley and Ridge provinces; and G. W. Crickmay—Crystalline rocks of the Piedmont and Highland provinces. G. W. Stose is editor.

By distinctive colors and patterns are shown 26 Coastal Plain formations, 18 Paleozoic formations, and 25 units within the crystalline rocks. The base map is the United States Geological Survey State map on a scale of 1:500,000.

Copies of the map will be displayed, and the principal features of the geology of the State will be discussed.

SPRINGS AND SPRING DEPOSITS OF THE LLANO UPLIFT AREA IN CENTRAL TEXAS

BY F. B. PLUMMER

Thirty large flowing springs occur around the Llano uplift in central Texas. The geological and structural conditions that produce these springs are discussed and illustrated. The travertine deposits around the springs are described, and observations on the mode of origin of the travertine are recorded. Several types of travertine are illustrated. Two epochs of travertine formation are recognized: An early very prolific accumulation, which is correlated with one of the upper river terraces and is of Pleistocene age, and a recent epoch of less prolific deposition which has produced beautiful waterfalls and cascades in many of the creeks fed by the springs.

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* Introduced by Nelson C. Dale.
† Introduced by Walter B. Jones.

ORIGIN OF THE GYPSUM SANDS OF NEW MEXICO

BY FRANKLIN C. POTTER*

The origin of the white (gypsum) sands in the Tularosa Basin, New Mexico, has been explained by geologists as due to different geologic processes. The available evidence including that of grain sizes is interpreted as supporting the following conclusions: (1) Gypsum from the Chupadera formation in the mountains was carried to the basin and deposited as valley fill by water; much of it was deposited in standing water. (2) Most of the gypsum sand was derived from the alkali flats as they were excavated by wind action; this action still continues. (3) The gypsum derived from the flats is original valley fill supplemented by gypsum washed to the flats by each rain, deposited on the surface by capillary action, and to a minor degree from the disintegration of the large selenite crystals west of the flats. (4) Additional gypsum is provided by capillary action within the dune belt.

PHYSIOGRAPHIC DIVISIONS OF CANADA

BY WILLIAM E. POWERS †

The major physiographic divisions in Canada remain essentially as delineated by Selwyn and Dawson in 1884, except in the Cordillera, where Daly, Kerr, and others have established subdivisions based on geologic and topographic facts unknown to Dawson. Since 1884 new knowledge of Canadian physiography has followed (1) introduction of the peneplain concept, (2) wide study of continental glaciation, (3) detailed information, particularly in the north and west, and lately (4) aerial photography. New physiographic divisions are the Hudson Bay and Arctic lowlands and the Arctic Archipelago.

These facts are noteworthy: (1) Origin, age, and geologic significance of the Laurentian peneplain and its eastern (Labrador) scarp are still uncertain, though characteristics of preglacial stream valleys shed some light. (2) Recent studies indicate that the Shickshock Mountains were glaciated by the Labrador ice sheet, thus reopening the question of local ice caps in Newfoundland and the Maritime provinces. (3) The relation of peneplains in Newfoundland and the Maritime provinces to the Laurentian peneplain is still problematical. (4) The pattern of postglacial uplift is difficult to reconcile with any assumed pattern of thickness of glacial ice. The bottom of Hudson Bay has a drowned dendritic system of shallow valleys. (5) The High Plains and Plateaus include residuals of high erosion surfaces, indicating physiographic unity with the Great Plains in the United States. (6) Numerous plateau and mountain units are present in the Cordillera, but their interrelationships are little known. The most significant boundary within the Cordillera is the Rocky Mountain Trench, which separates the Rockies of Laramide age from the interior ranges of Jura-Cretaceous deformation.

PHYSIOGRAPHY OF THE MORENO VALLEY, NEW MEXICO

BY LOUIS L. RAY AND J. FRED SMITH, JR.‡

The broad Moreno Valley parallels the trend of the Sangre de Cristo Mountains in northern New Mexico, east of the crest of the range. The axis of the valley follows in part the axis of a faulted, northward-plunging syncline.

Previous to the establishment of the valley there was developed, probably in Middle or Late Tertiary time, an erosion surface of low relief, now represented by

* Introduced by Earl A. Trager.
† Introduced by C. H. Behre, Jr.
‡ Introduced by Kirk Bryan.

broad mountain flats at elevations of about 10,000 feet. Above this surface rise the higher mountain peaks. Into this surface was cut a broad valley, evidences of which remain as high bedrock benches along the walls of the present Moreno Valley. Drainage was to the south, following the course of the Moreno and Coyote Creek valleys to the vicinity of Mora, thence southeastward into the drainage of the Canadian River. This early southward drainage was captured by the Cimarron River and diverted to the east through the present Cimarron Canyon and into the Canadian River. Drainage south of the point of capture has been reversed for about 14 miles, the present streams flowing northward to the Cimarron River.

Within the Moreno Valley there are at least three lower surfaces related to the present drainage. These are in part erosional and in part depositional. A bedrock divide separates the drainage of the Moreno Valley from the drainage of its former continuation to the south—the Coyote Creek Valley—which follows essentially the course established previous to the capture of its headwaters by the Cimarron River.

There is no evidence to support a belief in the existence of the Moreno Glacier, reported by R. W. Ellis to have occupied this valley. (Geological Society project.)

SEDIMENTS OF THE GULF OF CALIFORNIA

BY ROGER REVELLE *

The Gulf of California forms part of a modern geosynclinal trough into which the Colorado River has carried annually in recent years an average suspended load of about 250 million tons. Although it contains steep ridges and deep basins separated by probable fault scarps, the southern two-thirds of the Gulf consists essentially of a V-shaped trough sloping toward the south and having maximum depths of over 3000 meters. In the northern third of the Gulf the bottom topography has been flattened out and shallowed by accumulation of clastic debris so that a constantly shifting balance of sedimentational forces has been attained between the Colorado River and the strong tidal currents of the inner Gulf. Bottom cores taken in this northern area commonly consist of green muddy sands and silts overlying or interbedded with stiff brownish-gray clays (median diameter about one micron). The principal sources of sediments in the southern two-thirds of the Gulf are the remains of diatoms and other plankton organisms, which are extremely abundant in the overlying waters. Bottom cores are usually loose, flocculent, green muds, consisting very largely of diatom remains, frequently with the odor of H_2S, and often containing numerous alternating dark- and light-green, thin mud laminae, together with occasional thicker layers of well-sorted fine sand or silt. If lithified, such muds might become diatomaceous shales like those of the California Monterey series. Exceptionally high organic matter contents are found in cores from less than 1500 meters, corresponding to almost complete lack of dissolved oxygen in waters of these depths. Otherwise unaccountable variations in average particle size of the sediments seem to be correlated with currents in the deep water caused by internal standing waves set up by recurrent gales. (Geological Society project.)

CURRENT MEASUREMENTS NEAR THE SEA BOTTOM

BY ROGER REVELLE AND F. P. SHEPARD

During the past 2 years 20 series of bottom current measurements within a few feet of the sea floor have been carried out in the southern California region. Observations have been taken on the continental shelf, on banks, on deeply submerged ridges

* Introduced by Parker D. Trask.

and steep slopes, in submarine canyons, and large basins. The range of depths investigated was between 30 and 1900 meters, while periods of observation were between 3 and 36 hours. Over 900 individual measurements were made. The maximum current velocities observed in relatively deep waters were as high as those found in shallow areas and were of the same order of magnitude as that of most surface currents in the open ocean. There was no apparent difference in maximum velocity between various types of bottom topography or sedimentary cover. Where the bottom was rocky or sandy, however, the rate of decrease of velocity toward the bottom was greatest. Although tidal and wind currents played an important role in shallow waters, shifts in both speed and direction occurred at irregular intervals at all depths; in fact, nonperiodic changes in velocity were the most characteristic feature of the observed currents. These irregular movements may be regarded as representing lateral turbulence or eddy motion in which the eddies have vertical axes and are perhaps a few miles in diameter. (Geological Society project.)

BROADER FEATURES OF STRUCTURE AND PHYSIOGRAPHY OF THE WESTERN ANDES

BY JOHN L. RICH

The Andes, through almost their entire length, are remarkably uniform structurally and physiographically. Thrust from the west dominates and seems to be continuing along the eastern margin. Strips of metamorphic rocks are upthrust along the eastern side. In the central zone complexly folded and faulted unmetamorphosed sediments dominate, and along the western border, from the west side of the plateau to the Pacific, are volcanic rocks of early Tertiary age, with subordinate metamorphic rocks of "basement" type and intrusive rocks. This belt is characterized by "basin and range" structure and physiography.

The present height of the Andean region is not due to the original deformation but to relatively recent upwarp of a post-mature surface which truncates the folded sedimentary formations of the central zone and the early Tertiary volcanic rocks and the metamorphic rocks of the Pacific slope. The upwarping has produced a broad, flat-topped arch. Locally, as north of Santiago, the old surface slopes gradually to the Pacific, but in most places a distinct downwarp separates the high Andes from the "basin and range" area of the west. Locally, as in the nitrate region of northern Chile, the old surface drops from the crest to a broad upland trough, then rises gradually westward toward the Pacific where it breaks off to the ocean in a 2000- to 6000-foot escarpment.

Most of the active volcanoes lie along the downwarp at the west edge of the flat-crested arch. Post-uplift movements are not conspicuous; they were rarely observed except along the western coast between Antofagasta and Arequipa where remarkably fresh fault scarps are common.

METHOD OF COMPARING HEAVY MINERALS IN SEDIMENTARY DEPOSITS

BY GORDON RITTENHOUSE *

The proposed method of comparing heavy minerals of water-laid deposits is based on the sediment carried instead of the sediment deposited by streams. Because of greater specific gravity, grains of heavy minerals (except perhaps micas) are smaller than grains of light minerals of equal hydraulic value. As noted by Rubey this may cause marked differences in heavy-mineral composition in deposits of different average grain size and sorting derived from the same source. The ratio of the

* Introduced by W. W. Rubey.

amount by weight of a species of heavy mineral to the amount by weight of light minerals of equal hydraulic value remains constant for any given size regardless of the average grain size or sorting of the deposits of a stream and will change downstream only through differential wear or abrasion, selective entrainment or deposition, weathering during temporary deposition, or contamination from new sources.

The amount by weight of heavy minerals is obtained by determining the per cent by number of all heavy minerals in a sieve separate, correcting for specific gravity, and multiplying the total weight of heavy minerals in the separate by the corrected percentage. The amount by weight of light minerals may be obtained from the cumulative curve and the total sieve sample weight, provided the diameter of the light minerals of equal hydraulic value is known. To determine the equivalent diameters for various grain sizes of fluvial sands, arbitrarily selected diameters are being tested by determining the coefficient of variation for each on suites of samples from the Rio Grande.

HISTORY OF GEOLOGIC AND TOPOGRAPHIC MAPPING IN VIRGINIA

BY JOSEPH K. ROBERTS

The growth of geologic and topographic map making in Virginia is a fair index to the general progress in development of geologic thought in the State. Geological cartography of Virginia may be divided into four periods: (1) From 1782 when de Chastellux and his engineers studied Natural Bridge to 1840; (2) 1840 to 1890; (3) 1890 to 1908; and (4) 1908 to the present.

During this first period there were about 22 maps, but most of them treated Virginia as a portion of eastern United States, and the geology was that of a Maclurean kind. The base maps were few and inaccurate, and topographic maps had not appeared. The second period saw the appearance of the William Barton Rogers map. Though completed in the 1840's, it was not published until 1884 in desired form. Major Jed. Hotchkiss published many hachured county and local maps during this second period. The third period began with the United States Geological Survey publishing quadrangles on the scale of 1:125,000 and later 1:62,500, and 13 folios appeared. Maps of mining areas were numerous, but many were mere sketches of small areas. The fourth period dates from the reorganization of the Virginia Geological Survey in 1908 to the present. During this time the second and third geological maps appeared in 1911 and 1928 respectively, and to date about 50 reports have been published, each carrying one or more detailed maps. So, when the total of 970 maps from 1882 to the present are compared, the most impressive idea left is the great amount of progress made.

UPPER TILL, TWO BOULDER CLAYS, AND INTERGLACIAL FLORA ON CAPE COD

BY ROBERT W. SAYLES

This preliminary report enumerates the discoveries made by the writer. In 1937 the writer discovered a boulder clay under the latest till, with varves, sand, and gravel intercalated between them, at Nauset Coast Guard Station in Eastham. In 1938 the till and boulder clay were traced from Indian Neck, South Wellfleet, through Orleans, Pleasant Bay, to Chatham. In 1939 in the boulder clay, Larsen and the writer found sponge spicules, 16 species of warm-water marine diatoms, a radiolarian, and pollen grains of 20 species of temperate and warm-climate trees, all determined by Arthur S. Knox. In June a still lower boulder clay was discovered beneath the other beds, in an anticline 200 yards long at Indian Neck; in August these beds and two interglacial beds were distinguished at Nobscusset beach in Dennis. The two

boulder clays are weathered and discolored to an average depth of 2 feet, the grain is larger than in true clay in most places, and glacial pebbles, some with striae, show its glacial handling if not its complete glacial origin. Stratification is very rare; folding is general. Knox discovered at Nobscusset a layer of poorly preserved water-worn wood fragments in a bed of sand 2 feet thick between clay and the middle boulder clay. Knox found that associated with southern white cedar is a dark sand containing pollen of 18 trees indicating a climate as warm as or warmer than the present. The floras at Nauset and Nobscusset correlate perfectly.

ROCK SERIES IN DIABASE SILLS AT DULUTH, MINNESOTA

BY GEORGE M. SCHWARTZ AND ADOLPH E. SANDBERG

Above the large gabbro mass in Duluth are several typical Keweenawan sills intrusive into Keweenawan basalt and rhyolite flows. Three of the sills are large and consist of diabase in the lower portion and granite near the top. They were mapped in detail, and samples were selected for petrographic study and chemical analysis.

The sills consist essentially of two rock types—diabase and granite. There is a gradation mineralogically and chemically from the most basic to the most acidic facies. There is, however, a sharp break between the mineral and chemical composition of the granite of the sills and the rhyolite in the roof. The gradational zone within the sill consists mainly of diabase with various amounts of interstitial micropegmatite.

Five possible origins for the rocks in the sill are considered. These are: separate intrusions of basic and acidic magma, metamorphism of rhyolite, hydrothermal alteration of diabase, syntexis, and differentiation.

It is concluded that many factors may have had some effect, but that differentiation accounts for the major part of the segregation of the rock in the sills into two distinct facies. It is difficult to see how crystallization differentiation could produce the rock and relations found, but if liquid immiscible separations occur in magmas such a process aided by mineralizers might explain the origin of the facies in the sills. (Geological Society project.)

ARTIFACTS ASSOCIATED WITH EXTINCT VERTEBRATES IN BEE COUNTY, TEXAS

BY ELIAS HOWARD SELLARDS

The artifacts are found in Pleistocene stream terrace deposits which unconformably overlie Pliocene clays and marls. Both the Pliocene and Pleistocene deposits contain vertebrate fossils, and the discovery of artifacts was made while excavating for fossils from these formations. In the course of approximately one year of excavating, the Pliocene at this locality has yielded 10 skulls and many accompanying bones of a Pliocene mastodon, *Tetrabelodon buckneri*, n.sp., and, in addition, parts of the skeleton of Pliocene horse, camel, rhinoceros, and deer. The vertebrate fossils of the Pleistocene found at this immediate locality include *Parelephas columbi*, *Mastodon americanus*, and *Equus* sp. The break between Pliocene and Pleistocene fauna is complete. No one of the three genera from the Pleistocene has been found in the Pliocene, and, conversely, no Pliocene species has been found in the Pleistocene.

To reach the Pliocene bone bed, it is necessary to remove 22 feet of overburden of which the uppermost 15 or 16 feet is Pleistocene. In removing the Pleistocene, various flakes apparently made by man were observed from time to time, and on February 8, 1939, a spear was found at the base of the Pleistocene deposits, at a depth of 15.5 feet. Subsequently a considerable number of artifacts were obtained

including spears, scrapers, and other worked flints. The Pleistocene fossils and artifacts are from the 25-foot terrace of Blanco Creek. Terraces of this height in this part of the State usually, as at this locality, contain extinct vertebrates.

EP-ARCHEAN AND EP-ALGONKIAN EROSION SURFACES, GRAND CANYON, ARIZONA

BY ROBERT P. SHARP *

The buried Ep-Archean and Ep-Algonkian erosion surfaces of the Grand Canyon are outstanding examples of well-developed peneplains. The evidence of subaerial weathering on these surfaces and their low relief is notable.

The nature of the residual regolith on the surfaces shows that chemical types of weathering were dominant in the closing stages of the erosion cycle. Biotite and plagioclase have been decomposed, and the residual detritus consists chiefly of quartz, muscovite, clay, and hydrated iron oxides. The iron oxide content ranges from 0.9 to 12.8 per cent, and in some places a residual enrichment of iron appears certain. Moderately fresh potash feldspar in the weathered zone is attributed to removal of the overlying more maturely weathered material by the encroaching seas. The basal parts of the sedimentary beds burying the peneplains are composed largely of weathered detritus reworked from the immediately underlying rocks.

Various lines of evidence are cited to show that the climatic conditions toward the close of the Ep-Archean and Ep-Algonkian intervals were more humid than arid. The surfaces are clearly of subaerial origin. The most noticeable effects of marine erosion are the reworking of the weathered mantle and a sharpening of monadnock slopes. A spectacular slide breccia resulting from such erosion is described. A calculation based on the best available data indicates that approximately 100 million years were required to develop the Ep-Algonkian surface. The Ep-Archean surface may represent an even longer time span.

DEPTH CHANGES IN SUBMARINE CANYON HEADS

BY FRANCIS P. SHEPARD

A total of 22 accurate depth profiles have been established along ranges in the heads of eight submarine canyons off the California coast. During the past 5 years these profiles have been repeated as many as eight times to look for changes in the depths. Tests and checks of various kinds have been made to find the limit of error to be expected in repeating a sounding. Comparison of results shows that changes have occurred which greatly exceed the limit of error for individual soundings and changes which involve all soundings across a canyon in three continuous lines. Three types of changes have been definitely established: (1) A progressive fill with maximum change of 20 feet and lasting for as long as 4 years; (2) a deepening of as much as 18 feet on a canyon floor and with the process having a duration of at least a week; and (3) a slump from the wall of a canyon causing a total deepening of about 60 feet and an increase in the width of the canyon head, the process lasting for at least 7 days. On the other hand, at the end of a pier a deepening of 24 feet was completed within 2 hours. While all these movements have taken place in relatively shallow water, the deepening in some cases occurred during calm weather and without turbulent currents showing that it was not the result of water movements. Mud flows and slumping are thought to explain the deepening, while sedimentation accounts for the shoaling. The relation of these processes to canyon development will be discussed. (Geological Society project.)

* Introduced by T. T. Quirke.

AGE OF EXCAVATION OF NORTH AMERICAN SUBMARINE CANYONS

BY F. P. SHEPARD AND H. C. STETSON

Veatch and Smith date the excavation of certain Atlantic submarine canyons and other erosional features as postglacial and postulate a very recent lowering and rising of sea level to the extent of 12,000 feet. Whether or not the canyons were cut by subaerial processes, field evidence gathered by the writers is in direct opposition to the theory of so recent a widespread change of sea level either relative or absolute. Cores taken in canyons and on the continental slope of the east coast point to uninterrupted sedimentation at least extending back into the last glacial epoch. Nothing in the mid-Atlantic cores taken by Piggot indicates such a tremendous lowering of sea level. Since submarine canyons are also found in the Pacific, reference may be made to an 8-foot core of red clay obtained off the California coast. Furthermore, many of the canyons are cut in places clearly not related to land drainage.

However, opposed to an ancient origin of these erosional features are the Tertiary formations, mostly Miocene and Pliocene, which have been found in place on the walls of the California canyons, and the Cretaceous to Pliocene series which make up the upper parts of the walls in the Georges Bank canyons. Evidence from the California islands, and from a study of coastal and sea floor physiography, also points toward the Pleistocene as the time of excavation. Possible relation to a pre-Wisconsin glacial epoch is suggested by the large size of the canyons off the moraine-covered Georges Bank area.

SEISMIC STUDIES OF CRUSTAL STRUCTURE IN NEW ENGLAND BY MEANS OF QUARRY BLASTS

BY LOUIS B. SLICHTER

During the past year observations of five large quarry blasts have been made at about 30 different locations in New England by means of a group of 12 three-component portable seismographs. Instruments were spaced at suitably chosen intervals at distances between 1500 feet and 350 km. from the blasts. The orientation of the instruments was also adjusted to the direction of the source. To insure a precise time scale radio second signals were simultaneously recorded on all records. The records may be read to a precision of .05 second or less, if desired, which renders the identification of phases unusually certain. In the Connecticut Valley, after a superficial layer of low-velocity sediments was penetrated (near Meriden a local thickness of about 2 km., and a velocity of the compressional wave of 4.33 km./sec. is indicated) a layer of uniform wave velocity 6.32 km./sec. persists until a depth of 23.5 km., when the velocity increases to 7.82 km./sec. Comparisons between results obtained at different localities will be shown. The work is being continued, and most recent data will be presented. (Geological Society project.)

SAND DUNE CYCLE IN WESTERN KANSAS

BY H. T. U. SMITH *

The type of sand dune prevalent in western Kansas is essentially fixed from inception and is governed throughout its development by the agency of vegetation. Its evolution embraces two phases: eolian and eluvial. The eolian phase is one of dune growth, with wind action dominant. The unit form of the initial cycle is the primary blowout, consisting of two complementary members: an area of sand removal (commonly basined) and, marginal to it, a locus of accumulation, where

* Introduced by K. K. Landes.

drifting sand is arrested by the vegetal mat to form a sheet, mound, or ridge of sand.

The eluvial phase is one of degradation. It begins with the establishment of a vegetal cover sufficiently strong and continuous to check further wind action. Thenceforth the dominant processes are soil building, creep, and slope wash. Gradually the contours are rounded and simplified, the slopes reduced, the blowout depressions filled, the relief lowered, and the soil zone deepened. The dune area passes through stages of youth, maturity, and old age, eventually to be reduced to a faintly undulatory surface.

Interruption of the eluvial cycle and reversion to the eolian phase of a new cycle may occur at any stage through rupture of the vegetal cover and renewal of wind attack. This leads to dissection of primary dune forms by secondary blowouts, which assume a wide variety of forms.

Secondary blowouts, in turn, are subject to stabilization and reinauguration of the eluvial phase, which, again in turn, is subject to further interruptions.

SOLUTION EFFECTS ON LIMESTONE AS A FUNCTION OF SLOPE

BY J. FRED SMITH, JR., AND CLAUDE C. ALBRITTON, JR.*

Rectangularly jointed Cretaceous limestone forming dip slopes in the Sierra Blanca area of Hudspeth County, Texas, shows three main types of surficial weathering forms produced by solution. On slopes of 3 degrees or less tinajitas are the predominant type of solution cavity. On slopes of around 5 degrees a typical joint block shows a comparatively smooth surface whose downhill portion is essentially plane and whose uphill portion is concave upward, rising sharply to a crest situated at the uphill margin. On slopes of 20 degrees or more most joint blocks are creased with solution channels, generally separated by sharp crests.

Individual joint blocks are generally surrounded by gutters formed where joints between adjacent blocks have been widened. Most of the precipitation runs into these gutters, as a consequence of which the surface of each joint block is acted upon chiefly by the water that falls directly on it. Where bedding surfaces are nearly horizontal initial irregularities cause ponding of water and lead to the formation of tinajitas, from which dissolved material is removed by overflow. Solution on dip slopes inclined around 5 degrees leaves an upstanding crest along the uphill margins of joint blocks, since there is less solvent action on the uphill than on the downhill portions. On steeper slopes water falling on the joint blocks tends to course directly down dip in parallel rills which dissolve linear solution channels.

STRUCTURE OF THE MORENO VALLEY, NEW MEXICO

BY J. FRED SMITH, JR., AND LOUIS L. RAY *

The Moreno Valley about 16 miles east of Taos, New Mexico, has an area of approximately 100 square miles and trends north-south parallel to the regional structure of the Sangre de Cristo Mountains. Rocks range in age from pre-Cambrian granites and gneisses to unconsolidated Tertiary sediments.

Structurally the valley is a broad, northward-plunging syncline, disrupted by smaller folds and faults. The west side of the major fault, parallel to the axis of the valley, south of Eagle Nest Lake, is downthrown so that the Magdalena formation (Pennsylvanian) which occupies the valley floor is in contact with the pre-Cambrian granite gneiss of the eastern valley wall. On the western slope of Baldy

* Introduced by Kirk Bryan.

Mountain, north of Eagle Nest Lake, midway of the valley, the Pierre (Cretaceous) and Raton (Eocene) formations have similarly been downthrown by faulting. Less prominent faults occur along the western valley wall. East-west cross faults cut the valley in the vicinity of Eagle Nest Lake. All faults appear to be normal.

The major folding in this region seems to have taken place after the deposition of the Raton formation and prior to the intrusions of porphyry (post-Eocene—pre-late Tertiary). Some minor folds are the result of arching of sedimentary beds by intrusive porphyry.

Faulting was initiated in post-Eocene time and may have continued into the Pleistocene. A basalt flow in the southern portion of the valley appears to be faulted, and late Tertiary (?) sands, gravels, and clays along the eastern margin of the valley, north of Eagle Nest Lake, are deformed. (Geological Society project.)

REPRESENTATION OF MECHANICAL ANALYSES FOR DYNAMIC INTERPRETATION

BY EDMUND M. SPIEKER

The notable advances of recent years in mechanical analysis of sediments have been largely concentrated in laboratory techniques and means of representing results; interpretation, the main concern of the geologist, has had less attention. It is true that not enough is known about the complex dynamics of clastic sedimentation to justify extensive attempt at interpretation of size distribution, but it is known, at least, that one of the major dynamic factors involved is the settling velocity of the particle concerned. In the transportation of sediment the work done per unit time equals the product of weight times settling velocity of the material. To express particle distribution in terms of dynamic values, then, it seems logical to plot percentage weight against settling velocity, instead of against size, as hitherto customary. Not only is the ratio between size and settling velocity nonlinear, but, as worked out by Rubey and others, the pronounced changes in ratio fall in the very size ranges for which interpretation of mechanical analyses seems promising.

Scales based on settling velocities in water and air are proposed. Such scales, differentiating between the more delicate reactions to dynamic change of coarse material and the much more obtuse reactions of fine material, bring out features of various sorting patterns that are not evident on existing scales. Theoretical considerations possibly important in the use of this principle are outlined, and examples selected from existing analytical data to represent several sedimentary types are illustrated and discussed.

RAISED BEACHES ON EAST COAST OF JAMES AND HUDSON BAYS

BY GEORGE M. STANLEY *

Spirit levels were run from tidewater to the "marine limit" at two localities in Richmond Gulf, giving elevations of 875 and 815 feet. These places are 18 miles apart in an east-west line. If the highest sea level in both places was synchronous, as seems likely, the component of the tilt rate along this line shows a rise of about 3.3 feet per mile westward toward Hudson Bay rather than toward the Labrador peninsula, the last center of ice movement. Beaches of rounded cobbles and boulders were found in sporadic, topographically favored locations at seemingly all elevations below this "limit", and unstable, perched boulders are to be seen on

* Introduced by T. S. Lovering.

any hills above it. South of Lat. 55° 50′ N. neither the islands nor the highest hills of the coastal zone are high enough to have recorded the marine limit, and abandoned beaches may be found up to their summits. It is planned to continue the study about Richmond Gulf in order to round out the picture of the deformed marine limit water plane.

In several places driftwood was found on the old beaches up to surprising heights (85 feet); it suggests the recency of the later uplift and probably also the inactivity of decay in the cold climate. The effects of modern frost are tremendous; huge blocks have been disjointed from the bedrock and upheaved. Concentrated at certain spots on the brittle trap rock throughout the region, this action has built large cones and craters of frost-ejected blocks and debris.

GREAT EROSIONAL UNCONFORMITY IN THE KOHALA MOUNTAIN, HAWAII

BY HAROLD T. STEARNS

Kohala Mountain, 5505 feet high, about 21 miles long, and 13 miles wide, is an extinct volcano forming the northern part of the island of Hawaii. Its windward slope is cut by Waipio, Waimanu, Honokane, and Pololu valleys, four great amphitheater-headed valleys about 3000 feet deep. In addition their floors are drowned at least 1000 feet. The slope of these great canyons is composed of easily eroded basalts of the Kilauean type. The remainder of the mountain is mantled with more massive andesitic lavas and is studded with cinder cones and incised by a few relatively small gulches.

Partly filling Pololu Valley is a trachyandesitic flow several hundred feet thick. It terminates part way down the valley on a thick section of gravel. Tunnelling in the area northwest of this canyon has revealed smaller canyons under the andesitic mantle. Thus, the northeast slope passed through an erosion interval long enough for canyons more than 4000 feet deep to be cut between the basaltic and andesitic eruptions. Why the andesitic lavas completely mantled all but the northeast slope awaits further study, but it is suspected that formerly a high caldera rim protected the northeast slope from the andesitic flows and volcanic activity ceased soon after the caldera became filled.

DATING SEDIMENTATION, VULCANISM, AND OROGENY IN BEARTOOTH MOUNTAIN REGION BY HEAVY MINERALS

BY MARCELLUS H. STOW

The results of this project represent a further step in the demonstration of the chronologic relationship between time and manner of mountain uplift; time of notable volcanic activity; and time of accumulation of basin-fill sediments in the Bighorn Basin and Crazy Mountain syncline regions of southeastern Montana.

The investigation indicates that the stratigraphic units traced and mapped as Hell Creek, Tullock, Lebo, and Tongue River members of the Lance and Fort Union formations from significant fossil vertebrate localities in the vicinity of Polecat Bench and Heart Mountain, Wyoming, correlate with units designated as Hell Creek, Bear, Lebo No. 1 and Lebo No. 2, and Melville, respectively, in the Crazy Mountain syncline.

A series of agglomerates along the Yellowstone River is overlain by shales and sandstones of the Hell Creek. In some areas the agglomerates truncate beds of the Claggett, Judith River, Bearpaw, and possibly the Lennep; in other areas they are interfingered with these formations. Hence they signify a predominance of volcanic activity along the northern front of the Beartooths during this time interval.

Sedimentary petrographic studies show an absence of minerals derived from metamorphic rocks, which would seem to indicate that the crystalline core of the northwestern part of the Beartooth range had not been stripped of its cover of Paleozoic sedimentary rocks by the close of Tongue River time. (Geological Society project.)

ST. ANTHONY FALLS HYDRAULIC LABORATORY AND ITS USE IN GEOPHYSICAL RESEARCH

BY LORENZ G. STRAUB *

The St. Anthony Falls Hydraulic Laboratory of the University of Minnesota is situated on Hennepin Island at the head of St. Anthony Falls on the Mississippi River in the heart of Minneapolis. It is designed to operate by diversion of water from the Mississippi River above the falls through the laboratory and subsequently back to the river below the falls, after the water has served its purpose in the experimental study of various types of hydraulic occurrences. Projects in progress include experimental studies of sedimentation at the confluence of rivers, bed sediment transportation by flowing water in the light of fluid turbulence, investigations of flow conditions of the Mississippi River in the region of St. Anthony Falls as influenced by navigation structures (an operating model constructed to a scale of 1:50 has been set up for this investigation), percolation studies through granular materials, entrainment of air by water flowing at high velocities on steep slopes, and laminar-turbulent flow-transition region in open channels.

FLOW CLEAVAGE IN FOLDED BEDS

BY C. O. SWANSON

Field observations on flow cleavage in folded beds seem to favor the theory that the systematic orientation of the characteristic minerals is due to recrystallization under differential stress and not to laminar flow movements along certain planes. The general rule is that the flow cleavage is about parallel to the axial plane of the fold. However, complications are often found, and the indiscriminate application of this rule may show apparent contradictions. Several examples of such cases are given, and suggestions are made to help the field geologist to avoid certain errors in interpretation.

SUBSURFACE STRUCTURE OF THE PALEOZOIC ROCKS OF SOUTHEASTERN MINNESOTA

BY G. A. THIEL AND G. M. SCHWARTZ

Recent work by the Minnesota Geological Survey permits the construction of a detailed structural map of the southeastern part of the State with contours drawn on the Jordan-Oneota contact. The major structure is not the "Twin City" syncline as mapped formerly (Trowbridge and Atwater, 1934) but a series of gently dipping troughs, basins, and domes whose dominant structure is represented by a pitch southward.

In the region of the Twin Cities approximately 2500 square miles are underlain by a roughly circular basin around whose margin the Jordan-Oneota contact occurs at an elevation of 700 feet above sea level. The bottom of the basin, outlined by the 450-foot contour, is broad and flat. The average dip is about 20 feet per mile. The Hudson-Afton anticline modifies the structure of the east margin. Along the south

* Introduced by George A. Thiel.

edge of the basin an east-west-trending anticline extends directly across the area formerly mapped as synclinal. The area south of this structural high is characterized by a downward warping that formed a broad, gently pitching syncline whose major axis extends from southern LeSueur County southeastward into Iowa. There are three minor dome-like structures and smaller folds on the east limb of the syncline. The elevation of the Jordan-Oneota contact rises from 200 feet above sea level in the region of Austin to over 1150 feet on the crest of a local high to the southwest of Winona. Faults occur along the valley of the St. Croix River north of Stillwater and along the Mississippi valley at Hastings and Red Wing.

LATE GLACIAL VENTIFACTS OF CAPE COD*

BY LINCOLN R. THIESMEYER, RICHARD P. GOLDTHWAIT, KIRTLEY F. MATHER

More than 2000 ventifacts embedded in undisturbed glacial and fluvioglacial deposits and in disturbed surficial zones of western Cape Cod and contiguous areas of eastern Massachusetts were examined. They represent 35 lithologic types and vary from a quarter of an inch to 30 feet in diameter. All types of wind abrasion from incipient polishing and faceting to pronounced etching, deep fluting, or pitting are displayed. Some show that they were rolled during wind cutting, while others evidently split the wind so that several facets were produced on them simultaneously. The original shape of the fragments was the most important factor controlling present shapes of these ventifacts. Many show varying degrees of modification of their wind-scoured surfaces by abrasion during glacial and fluvioglacial transport.

The cutting of these ventifacts was in progress throughout the time of recession and local readvance of the ice, that is, during construction of the fluvioglacial landforms and both prior to and following formation of the various till masses of the area studied. General scarcity of wind-drifted material on the surface and in kettle-holes suggests that even the ventifacts in the upper soil zones were produced before complete disappearance of ice blocks. Freshness of the wind-cut surfaces corroborates other lines of evidence that the deposits containing them belong to later substages of Wisconsin time.

Thin weathering rims on some of the stones apparently survived glacial transport but were truncated sharply by wind-cut facets. Such stones bespeak caution in applying weathering of constituents as an age criterion for glacial drift.

PRE-CAMBRIAN IRON MINERALIZATION IN SOUTHEASTERN MISSOURI†

BY CARL TOLMAN AND CHARLES MEYER

The emplacement of the iron deposits in the pre-Cambrian felsites of southeastern Missouri was initiated by an early hematite stage which is best developed in the fissure fillings near the crest of Shepherd Mountain, Missouri.

Subsequently the iron-depositing solutions became reducing in chemical character, and partial conversion of the hematite to pseudomorphic magnetite was effected. Much primary magnetite, accompanied by minor amounts of sulfide, was also deposited during this second stage, both as tiny veinlets penetrating older hematite laths and as extensive fissure fillings and replacements such as those on Iron Mountain.

Late hydrothermal oxidation probably accomplished most of the observed martitization of the magnetite, since this reaction seems to have been induced by solutions

* Presented with the permission of the Director, U. S. Geological Survey.
† Published by permission of the Director, Missouri Geological Survey.

still capable of depositing late platy hematite. Martitization along the octahedral planes predominates at Iron Mountain, as evidenced by the lattice arrangement of hematite crystals which may be observed even though little magnetite now remains and no external crystal form may be present. Selective oxidation of concentric zones in magnetite crystals was also noted, as well as the common more irregular ingressions of hematite on magnetite without reference to crystallographic orientations or original crystal growth.

ORIGIN OF THE MUCK-SILT DEPOSITS AT FAIRBANKS, ALASKA

BY RALPH TUCK

The extensive gold-bearing gravel deposits in the Fairbanks district are covered with a muck-silt overburden varying from a few to over 200 feet thick. This overburden is economically important as (1) Its thickness is often a limiting factor in determining whether the underlying gold-bearing gravel can be profitably mined, as with large-scale mining methods it must be entirely removed. (2) The difficulty and cost of exploration have been increased because it has concealed many of the gold-bearing channels.

The overburden is of two types—muck and silt. The muck, which is frozen, occupies the present stream valleys and lies unconformably upon, or grades into, the silt, which is unfrozen and occurs on the lower hill-slopes. The inorganic material in the two types is essentially the same, but the muck contains about 50 per cent ice and vegetable material as well as an abundant Pleistocene fauna.

The origin of the muck and silt has long been obscure because of poor exposures and the complications of sub-Arctic solifluction processes. It now seems certain that the silt is of aeolian origin, while the inorganic material of the muck constitutes principally wind-blown particles that have been redeposited by creep, sheetwash, and stream action. A large part of the interior of Alaska is unglaciated; the deep muck-silt deposits occur in this unglaciated area and are probably a result of Pleistocene glaciation in nearby localities, as conditions were then ideal for aeolian deposition.

SURFACE OF NEWFOUNDLAND

BY W. H. TWENHOFEL AND PAUL MACCLINTOCK

The surface of Newfoundland is complex and owes its character mainly to work of erosive agencies on complex rock structure, differences in rock resistance, and periodic uplift. Depositional agencies are responsible for some parts of the surface. The most striking features are the slight relief of large areas of the upland surface and the rather generally steep slopes that rise from lowlands to uplands. Most steep slopes seem to be fault line scarps. Lowland areas are largely based on weak rocks.

The highest upland surfaces are on the west coast with elevations ranging from about 2000 to 2600 feet. The west side of the great central plateau has an elevation of from 1500 to 1600 feet, and its flat to gently sloping surface extends for many miles. This surface slopes to the east. It is 800 to 1000 feet high in the Red Indian Lake region and 400 to 500 feet high at Bishops Falls, Newfoundland Airport, and Shoal Harbor.

The west coast has a second upland elevation of level or nearly level surface in the range of elevation from 800 to 1350 feet.

The surface of the parts of the island studied is described in detail, a general summary of the data relating to the surface is made, and an interpretation or origin is attempted. (Geological Society project.)

PRELIMINARY REPORT ON THE CRETACEOUS AND TERTIARY LARGER FORAMINIFERA OF TRINIDAD, BRITISH WEST INDIES

BY THOMAS WAYLAND VAUGHAN AND W. STORRS COLE, WITH AN APPENDIX BY THOMAS F. GRIMSDALE

This paper, the first general survey of the larger Foraminifera of Trinidad, is based on very large collections sent to T. W. Vaughan by Mr. J. A. Bullbrook, an oil geologist in Trinidad, and Dr. H. G. Kugler, of the Trinidad Leaseholds Limited, between 1923 and 1938. The fauna as recorded consists of nine families; 15 genera, with 10 subgenera; 52 identified species; two varieties and one form; and 11 incompletely identified species. Two of the subgenera, 12 species, and one variety are described as new. In the appendix Mr. Grimsdale described a new species of *Helicostegina*. The genera that contain the largest number of species are *Operculinoides*, *Discocyclina* (with two subgenera), and *Lepidocyclina* (with four subgenera).

The investigation was undertaken primarily for the purpose of extending geologic correlations in the regions of the Caribbean Sea and the Gulf of Mexico. The horizons represented are as follows:

Lower Cretaceous, uppermost. Equivalent of the Albian
Orbitolina sp.
Upper Cretaceous
Lower Eocene. Equivalent to the lowest Wilcox or uppermost Midway of Alabama, with *Miscellanea* n. sp., near a species in the upper Ranikot of India, *Discocyclina*, 2 sp., and *Pseudophragmina*, 1 sp. The same fauna is also found in the lowest of the Scotland beds of Barbados (A. Senn collection).
Upper Eocene, Oligocene, Miocene } Equivalent formations in the Gulf States, Mexico, and the Caribbean region in general.
The faunas are tropical, neritic; temperatures between 77° and 84° F. (25° and 29° C); depths probably not over 50 meters.

PENNSYLVANIAN STRATIGRAPHY OF TENNESSEE, GEORGIA, AND SOUTHEASTERN KENTUCKY

BY HAROLD R. WANLESS

The Cumberland River drainage of southern Kentucky and the Tennessee and Georgia coal fields are divided structurally by the Pine Mountain and Rocky Face faults and the Sequatchie valley and Lookout valley anticlines into districts exhibiting marked differences in the Pennsylvanian section. Different names have been used for coals and other strata in these districts and additional names are used in the Kentucky and Tennessee portions of the same district. The section includes strata equivalent to the Kanawha, New River, and upper Pocahontas groups of West Virginia, and lower Allegheny beds are believed to be present in Harlan County, Kentucky. The Tennessee section is divisible into the following units named in descending order: Anderson, Scott, Jellico, and Briceville (restricted) formations of Kanawha age, Corbin, Duskin Creek, "Rockcastle," Vandever, Newton, Eastland, Herbert, Whitwell, and Sewanee members of the Lee formation, of New River age, and the Gizzard member of the Lee, equivalent to the Quinnimont (Lower New River) and a part of the Pocahontas. The section is several times thicker along the eastern escarpment of Walden Ridge and Cumberland Mountain than along the western border adjoining the Nashville dome, and a complicated series of overlaps may be observed in the western part of the Tennessee field. The Rockcastle conglomerate of Kentucky has been found to be equivalent to the Sewanee rather than to the higher conglomerate in Tennessee which has previously been known as the

Rockcastle. The Corbin conglomerate of Kentucky lenses out a short distance south of the Tennessee line. (Geological Society project.)

MULTIPLE GLACIATION OF MAUNA KEA, HAWAII

BY CHESTER K. WENTWORTH AND WILLIAM E. POWERS

Mauna Kea (13,784 feet), Hawaii, was glaciated four times during a period presumably correlative with the Ice Age elsewhere. Snow mantles Mauna Kea and Mauna Loa (13,680 feet) each winter. Snow banks persist through 11 months and occasionally on Mouna Kea throughout the year. No surface marks of glaciation are known on Mauna Loa; it is presumably of too recent volcanic growth to have been glaciated. But Mauna Kea bore glaciers during the latest glacial epoch and shows distinct indications of at least three earlier glacial advances, evidence for which was revealed by detailed observations in the zone outside the youngest moraine chiefly in the moderately dissected southwest sector of the mountain. The four indicated stages have been named, beginning with the latest, the Makanaka, Waihu, Pohakuloa, and pre-Pohakuloa stages. These names are drawn from localities on or near the summit area of Mauna Kea.

Distinguishing features of the several drifts are: (1) Stratigraphic position, the three earlier ones lying under successive series of late lava flows and often exposed only in the deeper gulch bottoms; (2) moderate weathering and surface staining (to brown) of the older drifts. Climate has probably been periglacial throughout Pleistocene and Recent time; (3) lithologic differences due to derivation from different series of surface lavas; (4) Matrices of the older drifts are partly tuffaceous, indicating contemporaneous volcanism; (5) In places the oldest drifts are well-indurated tillite; (6) The drifts are dominantly boulder beds, much water-washed. Boulders are somewhat faceted but only faintly striated, in general; (7) Striated pavements are known under the older drifts, but glacial erosion was generally feeble; (8) Glaciers in the Waihu and Pohakuloa stages descended to about 7000 feet; (9) Interglacial processes here other than extrusive vulcanism are little known. Climate is now sub-Arctic above timberline, and significant soils probably never were developed.

CONTACT RELATIONS BETWEEN RHYOLITE AND BASALT ON GARDINER RIVER, YELLOWSTONE PARK

BY R. E. WILCOX *

Intimate mixtures of rhyolitic material and basaltic material in rocks exposed near Seven-mile Bridge, Gardiner River, Yellowstone Park, have been attributed by Fenner (1938, p. 1441) to the assimilative effect of molten rhyolite as it flowed past the walls and bottom of a previously eroded valley in the basalt.

Recent field work in the area, including detailed mapping, has revealed the existence of an obsidian border zone of the rhyolite lying against an erosion surface on an older tuffaceous rhyolite. The obsidian zone is interpreted as a chill phase of the rhyolite and its "mixed rock." Since no such obsidian zone is found at the contact of the younger rhyolite and the basalt, it is concluded that both the younger rhyolite and the basalt must have been hot at the time they came in contact. Further, intricate flow textures and cloudy mixtures of the two types of rock imply that they were both more or less fluid or mushy when they came together. According to this interpretation, the effects seen would be due to the interaction of two hot lavas rather than the assimilation of a solid, already cooled basalt by a rhyolitic lava.

* Introduced by R. C. Emmons.

HARRISBURG AXIS, PENNSYLVANIA

BY BRADFORD WILLARD

The Harrisburg axis in south-central Pennsylvania was described briefly by Ulrich in 1911. Subsequent detailed studies of the Paleozoic systems of the State have added to knowledge of the limits, distribution, and character of the axis. In a region bounded roughly by the Susquehanna Valley on the west, the Schuylkill Valley on the east, and extending from Lancaster and York counties northward into Columbia County, irregularities of sedimentation chiefly among the Ordovician, Silurian, and Devonian systems, show that during much of the Paleozoic this was an intermittently positive area. Presumably because of these stratigraphic anomalies, structural irregularities were produced during or subsequent to the Appalachian Revolution.

STRUCTURAL FEATURES OF THE KEEWATIN VOLCANIC ROCKS OF WESTERN QUEBEC

BY M. E. WILSON

The Archean basal complex of the Noranda district, Quebec, consists chiefly of alternating belts of Keewatin rhyolite and andesite with subordinate amounts of pyroclastic breccia and stratified tuff. These rocks have been folded with increasing intensity from north to south into eastward-pitching anticlines and synclines. To the north, where the folding is moderate, the lava belts trend with a sinuous course from north to south and dip 45 degrees or less, whereas to the south, where the folding is intense, they trend east-west and have a vertical or nearly vertical attitude.

The structure of the lavas has been determined from the following data: (1) The trends of the flow belts; (2) the strike and attitude of interbedded stratified tuff and chert; (3) the trend and attitude of flow contacts within the flow belts; (4) the attitude of columnar jointage; and from (5) tops determined by the presence of: (a) zones of breccia along the upper margins of individual flows, (b) the rounded tops and flat bottoms of pillows of the "bun" type, (c) the rounded tops and V-shaped bottoms of pillows of the "balloon" type, and (d) cross-bedding in stratified tuff.

Within an area of 45 square miles extending from Noranda northward an uninterrupted succession of volcanic rocks, whose average total thickness is 25,000 feet, has been determined. It is proposed to call this succession the Abitibi series.

DEFORMATION IN THE BAGUIO DISTRICT, PHILIPPINE ISLANDS

BY EDWARD WISSER

The effects of a specific orogeny where exposures record a long geologic history are difficult to distinguish from those reflecting other deformations. The Philippine archipelago records mainly one orogeny, the effects of which are but little masked by those of other deformations; it forms, therefore, an exceptional field for the study of rock deformation.

Known geologic history starts with the Eocene. From that period to the upper Miocene, sediments, chiefly shallow-water, were continuously deposited in a geosynclinal trough that trended south through the center of present northern Luzon to a point east of what is now Manila, thence curving southeastward. The total thickness of these beds exceeds 15,000 feet.

Toward the close of the Miocene east-west regional compression intensely folded these sediments along north-south axes. Granitic intrusions, faulting, and mineralization accompanied the orogeny. At Baguio a north-south strip of Miocene sediments, between a granitic massive on the east and an andesitic massive on the west, was squeezed by the east-west compressive stress involved in the orogeny. The strip was

elongated north-south and deformed by flow and by horizontal displacements along steeply dipping faults in a manner suggestive of recent experiments on plastic deformation. The fracture pattern is symmetrical with respect to an east-west axis through the center of the district. North of this axis the squeezed ground moved north and, south of it, it moved south.

Veins formed during the period of east-west compression. Their localization and structure reflect the deformation at the time and place of their formation.

AUGUST MEETING AT BERKELEY

PROBLEM OF WILLAMETTE SOUND

BY IRA S. ALLISON

Condon based his theory of a Willamette Sound in Willamette Valley, Oregon, upon a proposed correlation of its valley fill with a marine terrace at Shoalwater Bay (north of the mouth of Columbia River), with a Columbia River terrace near Astoria, Oregon, and with certain sediments in valleys tributary to Columbia River near The Dalles, Oregon. Discovery of erratic glacial boulders, requiring transportation by icebergs floating in deep water, later added more substantial evidence of such a sound. On the other hand, the absence of shoreline markings, the lack of marine fossils in the valleys, the lack of well-formed marginal deltas, and the presence of mammalian fossils in the valley fill have left doubt on the theory.

The present paper attempts to evaluate and to reconcile these inconsistent lines of evidence. In spite of difficulties, such a sound appears to furnish the simplest explanation of the field data. Its bearing on glacial drainage problems of the upper Columbia River basin is also considered.

HAT CREEK LAVA FLOW

BY CHARLES A. ANDERSON

The Hat Creek lava flow issued from north-south fissures located 11 miles north-northeast of Lassen Peak, and the lava flowed northward for 16 miles, covering the floor of Hat Creek valley. Presumably the lava was erupted within the last few thousand years and represents one of the most recent basalt flows in the Lassen region. Only those at Cinder Cone are younger.

With the exception of certain vesicular phases and ejecta from spatter cones spaced along the feeding fissures, the basalt is holocrystalline with an ophitic or subophitic texture. Comparative studies of the crystalline and hypocrystalline basalt indicate that the olivine and plagioclase crystallized simultaneously and the pyroxene and iron ores are of late crystallization. In spite of the holocrystalline character of the lava, the flow possesses many characters indicating a marked fluidity at the time of eruption.

In chemical composition, texture, and masses of discharge, the recent Hat Creek flow is similar to the widespread Pliocene Warner basalt of northeastern California.

LATE TERTIARY VEGETATION AND CLIMATE OF THE GREAT BASIN AND BORDER AREAS

BY DANIEL I. AXELROD *

During Miocene a redwood forest flora lived in the northern Great Basin and adjacent areas, while an arid north Mexican flora ranged from southeastern California into northern Mexico. Late Miocene and early Pliocene elevation of the Sierra-Cascade Range resulted in a lower precipitation and greater extremes of temperature at the north, allowing a northward migration of the Mexican element. Members of this group are represented in the three generalized communities which may be distinguished over the province during early Pliocene: (1) The Transition forest of conifers and their regular associates at the north, (2) the oak-juniper woodland in the central part of the province, and (3) the desert-border flora to the south. The climate over the region was comparable to conditions now existent in areas where modern derivative vegetation of these communities exists.

* Introduced by Ralph W. Chaney.

Post-Lower Pliocene climatic changes over the province, due largely to the rising barriers to the west, resulted in the differentiation of the Transition forest into four climax coniferous forests. Certain members of the woodland and desert-border associations were limited southward, while others have survived to the present in areas of their former distribution. The woody components of the desert flora are largely of austral affinity, and the Great Basin sagebrush, which has become climax since Lower Pliocene, may also be of southern origin.

CONTACT GARNET FROM THE ADELAIDE DISTRICT, NEVADA

BY JULIAN D. BARKSDALE *

Ten miles south of Golconda, Nevada, a granodioritic stock has invaded a series of limestones, shales, and sandstones of uncertain age to produce a zone of extremely varied contact rocks. At one locality the limestone has been almost entirely changed to a crystalline mass of honey-colored to dark-brown garnet. The usual dodecahedral-trapezohedral crystal habit of garnet is rare but present. Complexly intergrown faces present striations similar in appearance to those on some pyrite crystals, suggesting a competitive alternation of faces during growth. By reflected white light, in hand specimen and in oriented thin section, a brilliant play of colors appears in some crystals. The phenomenon is comparable to the play of colors in labradorite, but the colors are more varied and they appear in bands. In thin section the garnet is weakly birefringent and under crossed nicols might easily be mistaken for twinned plagioclase. Index and specific-gravity determinations indicate the garnet to be in the grossularite-andradite range of composition. The cause of the play of colors is not as yet completely understood but is thought to be due to a combination of refraction and reflection from internal planes.

PROBLEMS OF APPALACHIAN GEOLOGY

BY ARTHUR BEVAN

Although Appalachian geology has been under more or less continuous investigation for more than a century, numerous major problems are still not solved beyond the possibility of interpretations other than those prevalent. Stated as interrogations, some of them are:

(1) Topographic character, position, and extent of Appalachia?
(2) Relations of Appalachia and Appalachian trough and seaways during successive epochs?
(3) Paleozoic distribution of earth segments now represented in the Appalachian provinces?
(4) Significance of the abrupt changes in Paleozoic sedimentation?
(5) Extent and character of Paleozoic sediments in present Piedmont and Coastal Plain provinces?
(6) Effect of the Taconic orogeny on Appalachian seaways?
(7) Time and space relations of Paleozoic igneous activity?
(8) Duration, sequence of phases, and causes of Appalachian Revolution?
(9) Sequence and causes in the formation of the patterns of major overthrust faults?
(10) Origin of Triassic basins, sources of contained sediments, environment of sedimentation, and relation to Appalachian drainage?
(11) Former westward extent of Coastal Plain sediments?

* Introduced by G. E. Goodspeed.

(12) Drainage history of the Appalachian region?
(13) Number, extent, dates, and preservation of true peneplains?
(14) Origin and date of the "Piedmont peneplain?"
(15) Upland conditions during Pleistocene time?

CONTRIBUTION TO THE HISTORY OF GLACIATION IN THE YOSEMITE REGION

BY ELIOT BLACKWELDER

Some modifications of current opinions are advocated in the light of evidence of which part is new and the rest reinterpreted. The paper is concerned largely with the length of the ice tongues in the three later glacial ages of the four commonly recognized in the Sierra Nevada. The glacier of the second (Sherwin or El Portal) age is thought to have extended at least 3 miles beyond El Portal, and that of the third (Tahoe or early Wisconsin) age to within about 3 miles of the same village. In the fourth and last (Tioga) age the Tenaya and Merced glaciers probably failed to reach the Yosemite Valley proper but discharged glacio-fluvial detritus which may have been chiefly responsible for the filling of Lake Yosemite. The evidence for these views is drawn from the profile of the river, the contour of the valley slopes, the glacial and other deposits, the seismic survey of the valley floor, and other considerations.

RUBBLE STRIPES ON THE FLANKS OF SEMIARID MOUNTAINS

BY ELIOT BLACKWELDER

Stripes and gores of broken rock debris on the soil-clad slopes of mountains in northern Nevada and similar regions are interpreted as the result of two alternating processes. In times of very infrequent heavy rain storms shallow gutters are eroded in the slopes, which are prevailingly covered with a thin soil insecurely held by the sparse herbage. During the long intervening time before the next flood, rock fragments gradually descending from disintegrating outcrops higher up the slope creep into and eventually fill these gutters, thus restoring the general surface to approximate equilibrium. The particular process of creep here involved is probably complex.

VOLCANIC BOMBS FROM NORTHERN ARIZONA CINDER CONES

BY L. F. BRADY AND ROBERT W. WEBB *

Numerous volcanic bombs containing accidental inclusions as cores were collected from several cinder cones in widely separated areas adjacent to the San Francisco Mountains in northern Arizona. Envelopes of cores are scoriaceous olivine basalt. Among the inclusions are dunites, peridotites, hornblende gabbros, hornblende andesites, quartz monzonites, granites, sandstones, and gneisses. The mineralogy of the hosts and inclusions are described. Mineralogical changes in cores include the inversion of quartz to tridymite in certain sandstone cores, the alteration of orthoclase, probably to sanidine, the production of glass from some grain combinations, and other changes. Textural and structural alterations of the included materials are discussed. Theories of genesis are suggested.

SPEEDS OF SEISMIC WAVES AND EARTH STRUCTURE IN CENTRAL CALIFORNIA

BY PERRY BYERLY

Least square adjustments of observations of waves of the P groups indicate the speed of $\overline{P}$ to be 5.61 km/sec. $\pm$ 0.05; that of P_n to be 8.02 km/sec. $\pm$ 0.05, and that

* Introduced by James Gilluly.

of P in the intermediate layer to be 6.72 km/sec. ± 0.02. The speed of $\bar{S}$ is 3.26 km/sec. ± 0.09. The depth of focus of the Berkeley earthquake of March 8, 1937, is fixed at 2.9 km. which allows the following determination of the average thicknesses of the upper layers of the earth's crust in the vicinity of the stations: Granite, 9 km.; intermediate, 23 km. The data from various earthquakes are interpreted as indicating a thickening of the granite layer south of the Berkeley region, the value of the thickness being 21 km. in the vicinity of San Benito and 24 km. in the vicinity of Parkfield. An explanation of the Z phenomenon is that P and S may have different foci, although for all but one of the shocks studied the Z phenomenon can probably be explained by errors. A reconsideration of the P_n data of the Nevada earthquake of December 20, 1932, together with new data, lead to the conclusion that the root of the mountain mass under the southern Sierra projects into the mantle beneath the surface layers by an amount between 6 and 41 km. (Geological Society Project.)

RECENT FAULT SCARPS IN THE WESTERN PART OF THE GREAT BASIN*

BY EUGENE CALLAGHAN

Recent fault scarps were mapped in a selected part of the Great Basin in the hope that a detailed study would shed light on problems of Basin-Range structure. The area chosen includes the group of en echelon ranges and valleys that branch from the Sierra Nevada between Mono Lake and Lake Tahoe. Field work was concentrated on scarps in Carson Valley, Antelope Valley, Smith Valley, and along the front of the Wassuk Range near Walker Lake.

The pattern of the scarps is complex, and there is wide variation in the amount of relative movement along the faults. Minor horsts and grabens and other details of structure are revealed by the distribution of the recent scarps in areas where their nature scarcely could be demonstrated otherwise. Normal faulting only was shown by the scarps. The relation of the recent fault scarps to physiographic forms such as fault hanging valleys, valley ridges, and pediments aids in understanding the genesis of features of the Basin-Range landscape. The results of the study, together with geologic and physiographic evidence, suggest that to a large extent the en echelon ranges in this area are parts of the once broad Sierra Nevada arch, which was invaded by Basin-Range faulting. The fault blocks outlined by this movement have rotated, allowing the range tops to maintain their equivalent position with respect to the Sierra Nevada arch, at the same time that the valley areas slumped along a system of normal faults. (Geological Society Project.)

UNUSUAL PORPHYRITIC DIKE NEAR BOULDER DAM, ARIZONA†

BY IAN CAMPBELL AND EDWARD T. SCHENK ‡

On the Boulder City-Kingman highway, 10 miles southeast of Boulder Dam, an exposed dike 4 feet wide intrudes deeply dissected fan gravels belonging to an older cycle of erosion. The fan gravels are only slightly indurated, yet the intrusion of the dike has resulted in no structural disturbance of the loose clastic materials, nor are thermal or other contact effects observable, even in the pelitic constituents of the fanglomerate. This indicates either a rather low intrusion temperature or that the permeability of the fanglomerate was so great as to dissipate immediately any possible pyrometamorphic effects.

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* Published with the permission of the Director, United States Geological Survey.
† Published with permission of the Director of the National Park Service.
‡ Introduced by J. P. Buwalda.

The dike is composed of strikingly large and fresh hornblende phenocrysts, measuring up to 4 inches in length, set in a hyalopilitic andesitic groundmass. The hornblende phenocrysts are practically absent from the chilled margins symmetrically developed along both walls of the dike but increase in size and in number toward the central portion. There is no evidence of multiple intrusions. The conclusion seems warranted that these phenocrysts are not intra-telluric but have formed after intrusion of the dike magma into approximately its present position, and that the size and number of the phenocrysts may have been controlled by the degree to which volatiles were trapped (as in the central portions of the dike) or were able to escape (as along the walls). Vesicles, containing zeolites and carbonate, are abundant in the central portions and, like hornblende, are lacking in the selvages.

EMPLACEMENT OF PLUTONIC INTRUSIONS IN THE SIERRA NEVADA WEST OF SEQUOIA NATIONAL PARK

BY CORDELL DURRELL *

Roof pendants of schist are embedded in plutonic bodies which range in composition from gabbro to granite. Individual plutonic masses average about 15 square miles in area.

The roof pendants, up to 15 miles in length, are exceedingly irregular in outline, with steeply dipping walls and nearly flat floors which are exposed in many places. Internal folds, both anticlines and synclines, are mappable and behave in a normal manner.

A zone of dike injection at the edges of the roof pendants passes into a zone of inclusions in the plutonic bodies. The plutonic bodies everywhere dip beneath the wall rocks.

Fold axes and thick sections of metamorphosed bedded rocks are truncated at intrusive contacts, and evidence of large-scale dislocation of wall rocks by plutonic bodies is totally lacking. Protoclastic structures in the plutonic rocks are also completely absent. Antistress minerals are found everywhere in the contact-metamorphosed facies of the roof pendants.

Migmatites, injection gneisses, and plutonic breccias occur locally along the contacts.

These data seem to require a passive mode of emplacement, and piecemeal stoping seems to have been the method operative at least in the later stages of consolidation. The method of opening of the magma chambers at an earlier stage may have been through assimilation. This is indicated by the local injection gneisses and by the general absence of stoped blocks in the central areas of the plutonic bodies. Evidently forceful injection played no part in intrusion.

SUBSURFACE STRUCTURE OF THE SAN JOAQUIN VALLEY, CALIFORNIA

BY WALTER A. ENGLISH †

During the last 5 years much structure mapping has been done by means of the seismograph in search of new oil fields in the San Joaquin Valley. While much of the data is still confidential, the broad features of the findings may be disclosed and are of considerable interest in bridging the gap between the Sierra Nevada type of structure on the east and the Coast Range structure on the west.

* Introduced by C. A. Anderson.
† Introduced by W. S. W. Kew.

DIALATION AND REPLACEMENT DIKES

BY G. E. GOODSPEED

A detailed study of a great many dikes in the Pacific Northwest, ranging from basalt and diabase to aplite and pegmatite, shows evidence for two contrasting mechanisms of dike formation—namely, dialation concomitant with magmatic injection, and replacement. Criteria for the recognition of both dialation and replacement dikes are presented. For the replacement type transitional facies are emphasized, since in the final stage definite characteristics of an earlier stage may be partially or wholly obliterated. There is a very great difference in the implication of simple magmatic injection as contrasted with the complex processes of metasomatism.

FACIES CHANGES IN THE UPPER MIOCENE OF SAN JOAQUIN VALLEY, CALIFORNIA

BY PAUL P. GOUDKOFF

The paper deals with the Delmontian and upper Mohnian strata of the San Joaquin Valley, which are well known for their extreme lithological variations. The problem of these variations has for a long time attracted the writer's attention because of its direct bearing on conditions of sedimentation.

On the basis of lithological and paleontological studies of material obtained from 125 wells and several surface sections the whole column has been divided into a number of units representing definite time divisions. An attempt has been made to define the principal types of microfaunal assemblages found in different parts of each unit, to appraise the ecological significance of these types, and to survey their distribution in relation to lithological variations of the sediments of each unit.

The results of the study are illustrated by 16 cross sections more or less evenly spaced between the southeastern end of the valley and the latitude of Visalia.

NEW EVIDENCE FOR CHANGE IN PHYSICAL CONDITIONS AT DEPTHS NEAR 100 KILOMETERS

BY B. GUTENBERG AND C. F. RICHTER

Seismograms of normal earthquakes show amplitudes for the direct longitudinal waves which decrease rapidly with distance to about 1500 kilometers; beyond this there is a sudden increase. Together with the corresponding travel times, this implies a decrease in velocity with depth at about 80 kilometers below the surface, which may possibly indicate a transition from the crystalline to the glassy state.

The station of the Carnegie Institution of Washington at Huancayo, Peru, records numerous earthquakes at short distances, many of which have focal depths from 50 to 250 kilometers. The amplitudes of longitudinal waves on these seismograms have been compared with each other and with those on records of the same shocks written at Pasadena. In this way the extent of the "shadow zone" of small amplitudes can be determined for various focal depths. For example, a shock distant 1300 kilometers at a depth of 90 kilometers shows very small amplitudes, while a shock at the same distance, but 110 kilometers deep, records with unusually large amplitudes. There is a limiting focal depth, apparently between 150 and 200 kilometers, such that earthquakes originating below this limit do not show the "shadow zone."

The results extend and confirm the previous conclusions from normal earthquakes and indicate that a slight decrease in velocity of longitudinal waves, either gradually or suddenly, occurs at a depth of about 80 kilometers below the surface. Travel times and amplitudes indicate that at greater depths the velocity again increases with increasing depth.

GEOLOGY OF THE SALINAS AND THE JAMESBURG QUADRANGLES, MONTEREY COUNTY, CALIFORNIA

BY C. LATHROP HEROLD *

The Salinas and Jamesburg quadrangles are in the central coastal region of California. Included are parts of the Gabilan Range and Salinas Valley and almost the full width of the northern Santa Lucia Range.

The crystalline basement consists of Sur and Gabilan (Paleozoic?) metasediments, intruded by Santa Lucia (Jurassic?) quartz diorite, and serpentine, intrusive into the foregoing. Upon this basement rest the following sedimentary formations: Chico, marine Upper Cretaceous; Church Creek, marine Eocene-Oligocene; Temblor, marine middle Miocene (including minor volcanic flows); Monterey, marine middle (?) and upper Miocene; Poncho Rico, marine Miocene-Pliocene transition; Paso Robles, continental Pliocene-Pleistocene; and continental Pleistocene and Recent deposits.

The area lies between the Sur and the San Andreas fault systems and contains no rocks of the Franciscan series with the possible exception of the serpentine bodies. Structurally, the northern Santa Lucia Range is characterized by a series of northwest-trending thrust faults which dip inward from both sides toward the center of the range. Post-Sur (Paleozoic ?) and pre-Tertiary structural disturbances are indicated, but definite dating is not possible in this area. The range attained its present form by uplift on the longitudinal thrust faults, which occurred in post-lower Miocene and reached a maximum in Pleistocene times. The northern Salinas Valley is a structural depression formed by the westward tilting of a block against the King City fault which forms the western margin of the valley.

TERTIARY HISTORY OF IVANPAH REGION, SOUTHEASTERN CALIFORNIA

BY DONNEL F. HEWETT

Archean gneisses and schists outcrop widely in the region. Pre-Paleozoic sedimentary rocks are known only in the northwest quarter, where a thickness of 5000 feet is recorded. Paleozoic sedimentary formations, representing a part at least of all systems, attain a thickness of 7500 feet in the eastern portion and 16,000 feet in the western portion of the area. Mesozoic sedimentary rocks, culminating in upper Jurassic sandstone, attain 8000 feet.

Laramide orogeny is represented by five major thrust faults that form a broad arc northeastward across the Ivanpah quadrangle. An extensive sill of quartz monzonite, intruded on a major thrust fault, and, therefore, Laramide in age, underlies 800 square miles. As no Eocene or proven Oligocene rocks are known, these epochs are probably represented here by erosion. Several thousand feet of rhyolite, latite, and basalt flows, as well as sedimentary formations of probable Miocene age, crop out widely in the eastern half of the quadrangle and sporadically in the western half. Numerous klippen of lower Paleozoic and pre-Paleozoic rocks rest on the Miocene(?) rocks within an area of 500 square miles in the northwestern corner and indicate extraordinary thrust faulting. Following this orogeny and possibly extending into Recent time there is normal faulting and broad warping. There are numerous Quaternary cinder cones and basalt flows.

AGE OF AN EROSION SURFACE IN SOUTHEASTERN CALIFORNIA

BY RICHARD H. HOPPER †

Recent field work in the Coso Range, directly east of the Sierra Nevada and south of Owens Lake, has resulted in the discovery of an erosion surface of low relief on

* Introduced by Howel Williams.
† Introduced by J. P. Buwalda.

the summit of the range. Portions of the surface were covered by basalt flows before the faulting to which the range owes most of its present height. The deposition of the basal fanglomerate of the Coso formation, which lies at low elevations around the edges of the range, was clearly induced by an uplift of the range after the development of the old-age erosion surface now preserved on its summit. Fossils in this basal fanglomerate (*Plesippus* and associated forms) establish the age of the Coso formation as late Pliocene or early Pleistocene.

Forty miles to the south is the type locality of the Ricardo erosion surface. Here the Ricardo surface, of very low relief, bevels tilted beds of the Ricardo formation which are dated as early Pliocene by their vertebrate fossils (*Hipparion mohavense* fauna). In the immediate vicinity of its type locality this surface has been partially buried by thin flows of basalt and has later been deformed, chiefly by block faulting, to create the present relief of the region.

From these data it is suggested that the Ricardo surface and the surface preserved on the summit of the Coso Range are of the same age and that they were developed by erosion during the interval between the deposition of the Ricardo and Coso formations.

PALEOZOIC SECTION IN THE ARGUS AND PANAMINT RANGES, INYO COUNTY, CALIFORNIA

BY RICHARD H. HOPPER *

A section is outlined of Paleozoic strata which has been measured during areal mapping in the northern Argus and central Panamint ranges. The total thickness of the Paleozoic beds exceeds 30,000 feet. All the named formations were originally described in Nevada. Units marked with asterisks have yielded determinable faunas.

PALEOZOIC	Approximate thicknesses in feet
*Lower Permian or upper Pennsylvanian limestone and shale *Pennsylvanian limestone and shale	8000
*Mississippian limestone (may include older strata)	4500
Section interrupted by faulting	
Devonian (?) limestone and dolomite, with conglomerate at base	1300
Disconformity (?)	
Silurian (?) dolomite	1500
Section interrupted by faulting	
Upper Ordovician Ely Springs (?) dolomite	300
Middle Ordovician Eureka quartzite	250
*Lower Ordovician limestone and dolomite Middle and upper Cambrian (?) limestone and dolomite	9000
*Lower Cambrian Wood Canyon formation (chiefly quartzite)	2600
Lower Cambrian Stirling (?) quartzite	1200
Lower Cambrian Johnnie formation (chiefly shale and slate)	1500
Nonconformity	
PRE-CAMBRIAN	
Schist, phyllite, quartzite, limestone, dolomite	15,000±

* Introduced by J. P. Buwalda.

DETERMINATION OF THE QUARTZ CONTENT OF INDUSTRIAL DUSTS

BY CARLTON D. HULIN

The determination of the quartz content of industrial dusts is important in preventing silicosis. Only particles of quartz under 10 microns, and particularly those from 5 to 0.5 microns or less, are harmful.

Methods of estimation of the quartz content of dusts in vogue are subject to large potential error. In particles whose diameter is one-sixth to one-sixtieth the thickness of rock sections, the optical properties used for microscopic mineral determination are relatively indeterminate. The exception is the index of refraction.

Accurate determination of the quartz content of dusts is possible using an immersion liquid showing extreme chromatic dispersion. This liquid matches the average index of quartz for red light (650 mμ) but is 0.024 above the quartz index for blue light (450 mμ).

Using transmitted white light, dust particles immersed in this liquid photographed at 600 diameters show images only of particles of index distinctly different from quartz; quartz particles do not register.

Twenty microns above focus the quartz particles have most of the blue light refracted (and diffracted) outside their images, which in consequence appear deep red. Using orthochromatic film these images photograph black; images of other particles also register.

The second photograph gives a count of all particles; the first of all particles minus quartz. Both show the same field, so the quartz percentage is known. Minerals of index close to quartz will report as quartz, so the result may be high—a potential error on the safe side.

The method is believed accurate to 5 percent.

FABRIC CRITERIA FOR DISTINGUISHING PSEUDO RIPPLE MARKS FROM RIPPLE MARKS

BY EARL INGERSON

Statistical grain orientation studies have been made on a number of unmetamorphosed ripple-marked sandstones, ripple-marked quartzites, and metamorphic rocks with pseudo ripple marks, some of which had been previously interpreted as ripple marks.

Quartz diagrams were prepared from all the rocks, and mica diagrams from the ones that contained mica. Without exception the axes of the pseudo ripple marks are important fabric directions, both for quartz and mica, whereas the axes of the actual ripple marks appear to bear little or no relation to the fabric.

The origin of the pseudo ripple marks is discussed, and the importance of fabric analysis in interpreting such structural features is indicated: Fold axes can be determined, or confirmed, from the microscopic fabric when megascopic data are not clear, and the direction of motion during deformation can be inferred.

GRAVITY SECTION ACROSS THE SIERRA NEVADA*

BY W. D. JOHNSTON, JR.

In 1939 the Coast and Geodetic Survey occupied 11 pendulum gravity stations, approximately 12 miles apart, extending from Sacramento to Reno across the northern part of the Sierra Nevada. Eight stations located upon predominantly granodiorite bedrock showed negative isostatic anomalies ranging from —5 to —44 milligals, and

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their average is of the same order as the average of the anomalies of the 46 pendulum stations in the California-Nevada block. Three stations, located upon the belt of Carboniferous and Jurassic strata, have positive isostatic anomalies ranging from +5 to +15 milligals. The positive anomalies are near areas of gabbro and are believed to reflect the excess mass of gabbro intrusive rocks extending downward from the surface to a depth of the order of 10,000 feet.

GEOSYNCLINAL NATURE OF CORDILLERAN DEVONIAN DEPOSITION

BY CHARLES KEYES

Recent revelation that the American Devonian deposition of the continental interior is of three-cycle character at once throws a new light upon the Cordilleran Devonian. Instead of a single, simple, stratal succession, spanning the entire Devonian period, there now appears to be three complete sedimental cycles of major order: An Early Devonian section comprising the Eastern Devonian of this country; a profound erosional unconformity of which there is no depositional equivalent in the continental interior region; and a Late Devonian sector embracing the whole of the deposition of this age west of the Mississippi River.

Lately, the determination of the diastrophic relations of major sedimentations gives clue to the genetic character of the Late Devonian deposits and their deposition in a restricted geosynclinal trough rather than in a global body of water. Contrary to the implication of paleogeographic maps, the Devonian geosyncline was a broad basin, oceanic in proportions, having its depth axis reaching from Alaska, through Iowa, to Alabama, and a width extending from Hudson Bay to the Grand Canyon, a distance of 2500 miles, or a basin comparable to that of the North Atlantic of today. Five miles of sediments filled this Devonian geosyncline, before they began to be uplifted and exposed to eroding activities.

CHARACTERISTICS OF THE HAYWARDS FAULT FROM OBSERVED CUTS AND TUNNELS

BY GEORGE D. LOUDERBACK

In recent years one of the important active faults, associated historically with strong earthquakes—the Haywards fault of California—has been intersected by several tunnels and cuts. The subsurface phenomena exposed in these excavations are believed to furnish important data which, added to those heretofore obtained by surface observations, give a more complete picture of the characteristics and progress of the faulting. The paper is based on observations made in the San Pablo tunnel, about 2½ miles north, and the Claremont tunnel, about 2 miles south of the University of California, a short tunnel and trench on the University campus, and certain tunnels and trenches excavated in connection with the Coyote Dam, about 25 miles southeast of San José. In none of these sections is a simple fault fracture or shear zone exposed, but an irregular succession of belts of shearing of various physical characteristics occupies a broad zone. The possible origins of these belts are discussed. The usual unique relation of one of the belts to specific topographic features is used as a basis for considering such a belt the locus of a succession of recent movements, and the practical aspects of such a conclusion are pointed out. Evidence of differential lateral movements, transverse to the direction of main faulting, seems to show that varied and more or less complex actions of spreading, compression, thrusting, and gravity faulting accompany and complicate locally the dominant action and may lead to incorrect inferences generalized from individual exposures.

STRATIGRAPHIC RECORD OF THE JURASSIC IN CENTRAL OREGON

BY RALPH L. LUPHER *

Eight formations have been recognized in the Jurassic sequence of central Oregon. A chronologic arrangement of these formations shows four formations in or near the Middle Lias, three in the early Middle Jurassic, one in the early Upper Jurassic, and one, of uncertain age, in the Upper Jurassic or Cretaceous.

A marked threefold lithologic grouping of the sequence appears very striking in the field, but this grouping does not correspond to the chronologic arrangement. The oldest lithologic division is composed mostly of shales and massive sandstones, over 2000 feet thick, at the isolated Donovan Ranch locality in the Silvies River Canyon near Burns. This includes the late Lower Lias "Hardgrave" red sandstone and its fauna which have been erroneously reported by Hyatt and others at a number of localities in central Oregon. The second lithologic division contains three of the Lias formations and one early Middle Jurassic formation at the base of the section in the main Jurassic area. It is characterized by thin, calcareous formations which abound in well-preserved fossils. The third division includes the remaining part of the Jurassic sequence, consisting of two formations of the early Middle Jurassic and one of the Upper Jurassic, as well as the uppermost formation of uncertain age. It is characterized by thick noncalcareous formations of massive sandstone and shale in which fossils are scarce and not well preserved.

HISTORY OF FAULTING MOVEMENTS AT THE EAST FRONT OF THE SIERRA NEVADA, AS INDICATED BY DISLOCATED MORAINES

BY F. E. MATTHES

The authenticity of the ancient moraine discovered by Blackwelder on the northwest shoulder of McGee Canyon, which has been called in question, is now definitely established, and a second moraine of the same early stage has been found in an analogous position on the north side of Lundy Canyon. The high altitudes and gentle gradients of these moraines are believed to indicate that the McGee stage of glaciation (Matthes' Glacier Point stage) took place before the canyons had been cut in the east front of the range, and presumably before the east front itself had been formed. However, it is evident that the Sierra Nevada in McGee time already was high enough to be glaciated on a large scale. It cannot therefore have risen several thousand feet since then, and the east front must have been formed chiefly, if not wholly, by downthrow of the country to the east of it.

Moraines of subsequent ice advances, cut off at different heights above the Mono Basin, occur at the mouth of Lundy Canyon, attesting successive faulting movements during the Pleistocene. Dislocated moraines occur also at many other points along the base of the range, as far south as Lone Pine Canyon, but the movements indicated were evidently various and local. This fact also implies downthrow of the broken country to the east rather than upthrow of the relatively solid sparsely fractured Sierra block.

STRUCTURAL PROBLEMS IN THE SIERRA REGION

BY EVANS B. MAYO

The crystalline rocks of the Tehachapi and San Emigdio mountains may hold the key to southern Sierra structure. In this corner, where the Sierra meets the San Andreas Fault and the Coast Ranges, the structure of the Tertiary rocks has been

* Introduced by Harold E. Culver.

mapped. This Tertiary structure suggests drag of the Sierra against the Coast Ranges. The crystalline rocks should be mapped to see if their structural pattern will confirm this suggestion.

In the metamorphic rocks on the western slope of the northern Sierra there are, in addition to the north-northwest regional structures, belts of nearly east-west folds that lie athwart the range. Granodiorite prongs, projecting westward from the pluton, follow the trends of these folds. Future studies in the northern Sierra should determine: (1) The origin of the nearly east-west trends, (2) whether these trends appear within the pluton, and (3) whether ore deposits of the Mother Lode are on intersections of nearly east-west trends with north-northwest shears or thrusts.

East of the Sierra it appears that intersections of northeast and northwest structures are loci of igneous intrusion, volcanic eruption, and ore deposition. There is need to sharpen this impression and to connect these Great Basin structures with the structure of the Sierra.

SAN ANDREAS RIFT ZONE IN THE SOUTHWESTERN PART OF SAN BENITO COUNTY, CALIFORNIA

BY RICHARD CHILDS MIELENZ *

In this region the San Andreas rift zone has a width of approximately one mile and consists of three main faults; the easternmost shows evidence of recent activity.

The distribution of various sedimentary formations is controlled by this rift zone. Within the zone are exposures of Franciscan (Upper Jurassic), Lower Cretaceous, Pliocene, and Plio-Pleistocene sediments. Immediately to the west, pre-Jurassic granites are overlain by approximately 2000 feet of McLure (Upper Miocene) shale followed conformably by 1000 feet of Lower Pliocene diatomaceous sediments. The latter are unconformably overlain by Plio-Pleistocene gravels. To the east of the rift zone the Franciscan series is overlain unconformably by Middle or Upper Miocene sediments ranging up to 500 feet in thickness. These are followed by at least 4000 feet of Lower and Upper Pliocene sediments which are quite unlike the Lower Pliocene sediments west of the rift zone. No McLure shales are exposed east of the San Andreas rift zone in the region studied.

Because of the lack of shoreline facies in the sedimentary horizons and because the Tertiary sediments show evidence of derivation from the north and northwest, it is believed that all these formations originally extended across the rift zone and that their subsequent removal was due to differential erosion made possible by repeated movements and reversals of movement along the faults of the rift zone. This implies a first period of faulting in pre-Upper Miocene time followed by a long interval of dormancy terminated by renewed activity in the Pliocene and Pleistocene.

MIARGYRITE CRYSTALS FROM RANDSBURG, CALIFORNIA

BY JOSEPH MURDOCH †

Study of recently collected miargyrite from Randsburg, California, has shown crystals richer in forms than from any locality but Braunsdorf, Saxony. Forty-six forms have been observed here, of which T (313) and Σ (322) are new for this species. α (233) and Z (205) confirm forms which have been reported as doubtful by earlier writers. A few of the crystals are as much as one centimeter across, but most of them are considerably smaller.

* Introduced by N. L. Taliaferro.
† Introduced by William J. Miller.

FORMULA AND STRUCTURE OF RALSTONITE

BY ADOLF PABST

The unit cube of ralstonite has a lattice constant of 9.87Å. This unit contains 48 (F, OH), 16 (Al, Mg), 2.7 Na and $7H_2O$. The space group is O_h^7, and the structure is similar to that of members of the pyrochlore group.

MARTINEZ (EOCENE) WHITE SAND, CONTRA COSTA COUNTY, CALIFORNIA

BY FRITZ PUTLITZ, WILLIAM A. NEWTON, AND IRA KLEIN *

Comprising a part of the type Martinez formation of Contra Costa County, California, is a white sandstone outcropping on the northeast flank of the Pacheco syncline near Vine Hill. It is 50 feet thick and occurs 1600± feet stratigraphically above the glauconitic sandstone with *Turritella pachecoensis*. The top of the sandstone is 700± feet below a foraminiferal faunule in shales in the upper part of the Martinez formation which contain the foraminiferal assemblage of Cushman and Barksdale (1930) from locality 322, and which Clark and Vokes (1936) call "Capay."

The light minerals are the following: quartz, 69 per cent; orthoclase, 19 per cent; chalcedony, 11 per cent; and one-half of one per cent each of microcline and plagioclase. Heavy minerals constitute less than one-tenth of one per cent by weight of the sample. Magnetite and zircon are most common, with minor amounts of epidote, garnet, biotite, and tourmaline also present. The sandstone is poorly sorted, the grains ranging in size from silt particles to medium sand. One-third of the constituents is finer than 200 mesh.

The mineral analysis and stratigraphic position of this sandstone may be of significance to those confronted with the stratigraphic problem of the white sandstones of Eocene age in California, many of which are designated "Ione."

ORIGIN OF KILBOURNE HOLE, NEW MEXICO

BY PARRY REICHE †

Kilbourne Hole, the larger of the two "Afton Craters," was described by Lee in 1907. It is of irregular shape, with a mean diameter of nearly 1½ miles, a depth of about 300 feet, below the general level, and a nearly encircling rim which rises in places 150 feet above it. On the basis of ejecta exposed in the rim, the origin of the Hole by steam explosion has heretofore been favored. Recent study establishes a more complex history, of which the final episode, responsible for the present land form, was subsidence. Attendant circumstances, suggestive but inconclusive, favor solution and collapse as the cause.

QUATERNARY HISTORY OF LOUISIANA

BY RICHARD JOEL RUSSELL

Five Pleistocene glaciations lowered sea levels sufficiently to rejuvenate the Mississippi River system, enabling it to cut valley systems in Louisiana 100 to more than 300 feet deep. Rising seas of waning glaciation permitted alluvial drowning of these valley systems and the deposition of five Quaternary formations.

Regional tilting, caused by subsidence of the deltas and a compensating elevation inland, has preserved the surfaces of the four Pleistocene formations as terraces, which extend continuously both coastwise and inland along major streams. In central

* Introduced by Hubert G. Schenck.

† Introduced by C. A. Anderson.

Louisiana the oldest surface slopes at 10 feet per mile, younger surfaces at rates of about six, two, and one feet. The Recent surface slopes at less than half a foot. Slopes of terraces flatten inland, and intervals are more constant in northern Louisiana. Slopes steepen coastward, particularly toward later deltas, and each formation passes below more recent deposits.

Basal gravels of each formation have been identified under the Recent deltaic plain, and positions of maximum deposition have been located for four of the five Quaternary formations. Each of these positions is characterized by lenticular thickening downward, so that at least three of the formations attain a maximum thickness of about 3000 feet. Each lens marks the position of the delta of its period. No two center in exactly the same place.

Seven subdeltas of the latest Recent have been identified, heaviest deposition being centered southeast of Baton Rouge. The highest land of the lower Mississippi Valley is in southwestern Mississippi, the result of subsidence of the Recent delta.

OIL FORMED FROM GASTROPODS

BY HYRUM SCHNEIDER

Near Thistle, Utah, about 65 miles southeast of Salt Lake City, in the Flagstaff limestone of the Wasatch formation a sandy bed about 20 feet thick is saturated with residual oil. In close association with the petroliferous sandy bed there are numerous gastropod fossils suggesting that the oil may have been formed from gastropods.

Stratigraphically below the petroliferous sand in limestone entirely free from oil are numerous lime concretions around gastropod shells. Most of the concretions contain simply gastropod shells without a vestige of anything that looks like oil. Occasionally a concretion contains, inside the gastropod shell around which the concretion was formed, a dark sticky viscous liquid that chemical tests show to be oil. The dense character of the lime in the concretions that enclose the oil, the fact that most of the concretions contain no oil, and the absence of oil in the rock that surrounds the concretions indicate that the oil found in concretions must have been formed from gastropods that were still in their shells at the time the concretions began to form around them. This further suggests that the petroliferous material in the adjacent sandstone, although different from the oil in the concretions, may have been formed from gastropods.

PETROLOGY OF THE BALAKLALA CHONOLITH, SHASTA COUNTY, CALIFORNIA

BY GEORGE F. SEAGER *

Certain of the igneous masses exposed in the southern Klamath Mountains have long attracted attention because of their distinctive petrologic features, their bearing upon the general geologic history of the Klamaths and northern Sierra Nevada, and their genetic relationship to mineral deposits. Among these is the Balaklala intrusive, of late Jurassic age, which lies west of the Sacramento River and includes all the known copper deposits of the western part of the Shasta County copper belt.

Chemically, the rocks of the Balaklala intrusive are distinctive in their very high silica and abnormally low potash content; mineralogically, the almost invariable occurrence of sodic plagioclase, generally albite, and the absence of primary mafic constituents are noteworthy. Microscopic evidence, both mineralogical and textural, rather conclusively indicates that the rocks are the product of widespread and

* Introduced by Alan M. Bateman.

thorough albitization of types bearing originally a more calcic plagioclase, presumably by soda-rich hydrothermal solutions which permeated the mass in late magmatic or early post-magmatic time.

Studies of the hydrothermally altered rocks both near and remote from the ore deposits indicate that the different altered products can be attributed to rather definite progressive alteration, chiefly with the development of mineral assemblages stable under the existing new conditions.

Breccias of both intrusive and cataclastic origin are of genetic significance, not only with regard to their own origin and time of development, but also with respect to the localization and age of the metallization.

NONDEPOSITIONAL SURFACES OFF THE CALIFORNIA COAST

BY FRANCIS P. SHEPARD

Recent explorations on the Scripps Institution vessel have confirmed the impression obtained from previous work that there were extensive areas off the California Coast where deposition is either very slow or nonexistent. Dredging and coring operations show either rock bottom or very thin sediment cover on most of the deep banks off Southern California, on many steep submarine slopes, on the walls and even on the floors of submarine canyons, and on the outer portions of the continental shelves. Depth seems to have little bearing on these occurrences. Further possible evidence of absence of important deposition comes from the finding of sand and gravel in very deep portions of submarine canyons where mud should be the chief sediment. Sand was discovered even in portions of the troughs and basins off Southern California at depths ranging around half a mile. This sand is significant because the chief sediment being supplied to the deep areas at present, insofar as can be determined, is silt and clay. The importance of bottom currents and of submarine mud flows in preventing deposition will be discussed. (Geological Society Project.)

STRATIGRAPHY AND INSOLUBLE RESIDUES OF THE MADISON GROUP OF MONTANA

BY LAURENCE L. SLOSS *

The Madison group comprises three Lower Mississippian formations totalling 500 to 1800 feet. The group is prominently exposed in the mountainous areas of Montana and is encountered at depth in the plains areas where it is locally oil producing. The lowest unit, the Paine formation, consists of interbedded thin cherty limestones and calcareous shales. A basal member of black conodont shale is present in some localities. The Woodhurst limestone is a series of well-bedded blocky limestones with numerous massive zones composed almost entirely of fossil fragments. The extremely massive poorly bedded upper unit—the Mission Canyon limestone—is recognized by bold solution-pitted cliffs.

Although the Madison limestones are highly fossiliferous the enclosing matrix is such that suitable fossils for identification are difficult to obtain, and paleontologic correlation is hindered. The absence of an adequate microfauna coupled with slight lithologic variation over a wide stratigraphic range has made accurate subsurface stratigraphy impossible. Methods of correlation by insoluble residues have been applied to these Montana limestones with encouraging results. Drill cuttings and samples collected from accurately measured sections were digested in hydrochloric acid, leaving a residue of quartz grains, minute quartz crystals, glauconite, clay and chert molds of dolomite crystals, chert fragments, a variety of accessory minerals, and silicified fossil fragments. Assemblages of these residue components have been

* Introduced by Eugene S. Perry.

found to be diagnostic in defining and correlating zones in the Madison limestones over fairly wide areas.

OROGENIC HISTORY OF CENTRAL NORTH AMERICAN CORDILLERA

BY EDMUND M. SPIEKER

Investigations of recent years in the Great Basin and bordering areas to the east show the orogenic history of this region to comprise, instead of two or three concentrated "revolutions," a series of orogenic episodes, beginning in the Upper Triassic and extending to the late Tertiary. At least nine individual compressional movements are now distinguished, and the total may be fifteen.

Folding apparently began in the Upper Triassic, in the western part of the Great Basin, and spread eastward. Succeeding movements were as follows: (2) early and (3) late Jurassic, in the western Great Basin; (4) mid-Cretaceous (early Colorado?) in the eastern Great Basin, probably from southern Nevada to southeastern Idaho; (5) possibly late Colorado (Niobrara) in central Utah; (6) late Montana, central Utah (early Laramide) and possibly elsewhere to the north; (7) middle Paleocene of vertebrate paleontologists, central Utah, possibly also the monoclines of the Colorado Plateau; (8) early Eocene, northern Rockies (late Laramide), with subsidiary movements through the Eocene; (9) mid-Tertiary (post-Eocene) thrusting in central Utah; and (10) late Tertiary thrusting in a belt from southwestern Utah to southwestern Wyoming.

Geosynclines seem also to have migrated eastward, and in central Utah by late Mesozoic time the geosyncline exceeded 40,000 feet in depth. None of the accurately dated movements falls on or near a major chronologic boundary. The effects of even the strongest orogenies were local.

FOSSIL VERTEBRATES FROM THE SUPERJACENT DEPOSITS NEAR KNIGHT'S FERRY, CALIFORNIA

BY R. A. STIRTON AND H. F. GOERIZ

Pliocene vertebrates have been obtained from the andesitic tuffs and clays of the Sierra slope at three localities.

A *Nannippus* tooth from near Goodwin Dam, and other fossil vertebrates from Two-Mile Bar, are either Lower or early Middle Pliocene in age. It will be necessary to obtain more material to clear up the age relationships of these assemblages.

A Middle Pliocene assemblage from the other locality includes: *Pliohippus, Neohipparion, ?Sphenophalos,* and a sciurid. It shows very close similarity to forms obtained from the Pinole Tuff of the San Francisco Bay area.

PALEONTOLOGICAL STRATIGRAPHY OF ARIZONA: ITS RELATION TO ADJACENT AREAS

BY ALEXANDER STOYANOW

This paper discusses the relation of the paleontologically characterized Paleozoic and Mesozoic strata of Arizona to those of California, Nevada, Utah, New Mexico, Texas, and Mexico. Special attention is given to the nature and distribution of corresponding seaways and land masses.

PROTOCLASTIC BORDER OF THE COLVILLE BATHOLITH, WASHINGTON

BY A. C. WATERS AND KONRAD KRAUSKOPF

In the Okanogan Highlands of northeastern Washington the Colville batholith, a rudely equidimensional mass approximately 60 miles across, injected a thick series

of sedimentary and volcanic rocks of Paleozoic and early Mesozoic age. These rocks had been severely folded and subjected to mild dynamic metamorphism before the intrusion. Along the sharply discordant contact the country rocks are much fractured and faulted, but contact metamorphism is commonly slight or absent.

The batholith is remarkable for its petrographic and structural heterogeneity. Around a homophanous central mass, principally granodiorite, is a belt commonly several miles wide of granodiorite with well-developed platy structures. Over broad areas the platy structures show the intricate swirling characteristic of ptygmatic folds. Axes of swirls are locally integrated into a fairly definite linear pattern. In other areas swirling is less conspicuous; here the rock is commonly porphyritic, containing fractured and strained phenocrysts of microcline.

The swirled gneiss passes gradually into a peripheral belt of well-foliated gneisses showing severe crushing and granulation. Over broad zones the rock is a protomylonite; locally recrystallization has produced types resembling metamorphic granulites. That the crushing was protoclastic rather than cataclastic is proved by relations with the wall rocks and by widespread cementation of the broken materials by films and stringers of undeformed quartz and microcline.

Relations of the gneiss to its wall rock and the nature of the crushing are believed to be best explained by the rise of the batholith as an almost solid mass following nearly complete crystallization.

METCHOSIN VOLCANIC ROCKS IN OREGON AND WASHINGTON

BY CHARLES E. WEAVER

The type section of the Metchosin volcanic rocks occurs in the southeastern part of Vancouver Island. These lavas form prominent surface exposures in parts of the Puget Sound Basin, the Olympic Peninsula, southwestern Washington, and in the Coast Range of Oregon as far south as the Klamath Mountains. These lavas are of middle and possibly early Eocene age and range from 1000 to over 3000 feet thick. They accumulated as submarine flows on a coastal plain whose surface was formed of the beveled edges of folded Cretaceous and older rocks. This thick accumulation of lavas may represent nearly 10,000 cubic miles of rock. Upon these lavas accumulated from 4000 to 8000 feet of marine sedimentary rock. During the Tertiary that part of the earth's crust from Vancouver Island southwest to the Klamath Mountains in Oregon subsided from 7000 to 11,000 feet beneath sea level. Late in the Tertiary this entire sequence of lava and overlapping marine sediments was elevated and folded into northwest-trending structures which later were greatly eroded. The Olympic Mountains probably represent one of these major folds. The volume and extent of the lava flows in the Columbia River Basin during middle Tertiary time are well known. The importance of the great sequence of Metchosin Eocene volcanoes farther west, although of lesser volume and extent, are worthy of attention.

GIANT ANDALUSITE IN PEGMATITE FROM RIVERSIDE COUNTY, CALIFORNIA

BY ROBERT W. WEBB *

Two new occurrences of the somewhat unusual association of andalusite in pegmatite have been reported from California in the past 3 years. Recently a large pegmatite dike containing imperfectly formed individual crystals of andalusite with average sizes of 3 by 3 by 6 inches common, in radial aggregates, and large parallel crystal growths, were found in a large schorl-bearing pegmatite near Hemet, in River-

* Introduced by William J. Miller.

side County, California. The mineralogy, petrogenesis, and field relations are now being investigated.

AGE OF THE DEKKAS VOLCANIC ROCKS OF THE KLAMATH MOUNTAINS

BY HARRY E. WHEELER *

The Dekkas andesite of supposed Triassic age overlies the Permian Nosoni formation in the southern Klamath Mountains and is overlain by the Middle? Triassic Pit shale.

The discovery of an unconformity between the volcanic and Pit sequences involving the development of thick basal Pit conglomerates, and the absence of lava above the unconformity, suggests a post-Dekkas and pre-Pit erosion interval of appreciable duration. In addition, the remarkable similarity of these relationships to those in the Humboldt Range of northwestern Nevada and in the northern Sierra Nevada, where the volcanics are of known Permian age, forces the conclusion that these Klamath Mountain effusives and pyroclastics should also be assigned to the Permian.

TERTIARY STRATIGRAPHY OF THE DAYVILLE QUADRANGLE

BY W. D. WILKINSON †

The completed areal map of the Dayville Quadrangle in central Oregon shows an unusually complete geologic section including Mississippian, Permian, Upper Triassic, Jurassic, and Upper Cretaceous marine formations. The nonmarine formations of this region south of the Ochoco Range include the John Day, Columbia River basalts, two Neocene formations not yet definitely correlated with either the Mascall or Rattlesnake of the John Day Basin, and a late Tertiary or Pleistocene series of basaltic flows apparently unrepresented within the Picture Gorge or Mitchell quadrangles north of the Ochoco Range.

AGE OF CRATER LAKE, OREGON

BY HOWEL WILLIAMS

The caldera containing Crater Lake was formed by collapse of the summit of the volcano Mount Mazama, following violent eruptions of pumice and scoria. The date of this catastrophe may be estimated approximately from the following criteria: (1) Size of the glaciers on Mazama at the time of the last pumice eruptions, as indicated by the distribution of the ejecta; (2) degree of erosion of the pumice and scoria deposits infilling the old glacial canyons; (3) character of the vegetation destroyed by the pumice; (4) degree of erosion of the caldera walls; (5) presence of human remains and artifacts beneath pumice; (6) relation of pumice to lake deposits in the neighboring lowlands; and (7) age of the last eruptions of the post-caldera cone of Wizard Island, as indicated by the oldest living trees.

Taken together, these criteria suggest that the engulfment of the top of Mount Mazama occurred no more than a few thousand years ago, long after the period of maximum glaciation, and when the adjacent parts of Oregon were already inhabited by man.

* Introduced by Vincent P. Gianella.
† Introduced by E. L. Packard.

ABSTRACTS OF THE PALEONTOLOGICAL SOCIETY

DECEMBER MEETING AT MINNEAPOLIS

PRIMATE FROM THE AMERICAN OLIGOCENE

BY JOHN CLARK

A new species of anaptomorphid primate, based on a jaw collected from the Chadron of southwestern Montana, is here described.

CHESTER INDEX OSTRACODES*

BY CHALMER L. COOPER

Since the discovery of petroleum in the Illinois Basin, considerable attention has been given to criteria for the recognition of the various Chester (Upper Mississippian) formations and their correlation. Since the ostracodes form a large part of Chester microfaunas, the study of them is important to determine their value as index fossils. This paper will trace the varying specific characteristics of a number of Chester ostracode genera through these formations.

POSSIBLE EVIDENCE OF "PRE-HISTORIC" MAN IN SOUTHEASTERN MISSOURI

BY CAREY CRONEIS

The writer, with the assistance of members of various summer field classes, has for a decade been sporadically investigating various geological features of a wide-mouthed cavern in Ste. Genevieve County, Missouri. Because of the character of the cave's outer chamber diligent search has been made for evidences of early habitation by man. During the 1939 field season there was discovered calcareous tufa containing not only both vertebrate and plant remains, but also numerous charcoal fragments. Inasmuch as the tufa occurs in a geological position suggesting some antiquity, and at a cave location unfavorable to the possible inclusion of charcoal resulting from fires not made by man, the suggestion of "early" human occupancy is reasonably strong. Results of a preliminary examination of the associated fossils at least do not weaken the other evidence supporting the thesis that the tufa cannot be very recent. For these reasons, and because of the compelling interest in the general subject, this possibly premature preliminary announcement is made regarding a subject which is, of course, being investigated in detail.

LATE CAMBRIAN FAUNAS FROM FORTUNE BAY, NEWFOUNDLAND

BY B. F. HOWELL

Field work of the Geological Survey of Newfoundland has led to the discovery around Fortune Bay, southern Newfoundland, of three Late Cambrian faunas, which can be correlated with the *Agnostus pisiformis, Olenus truncatus,* and *Peltura scarabaeoides* faunas of other regions in northwestern Europe, northeastern United States, and Conception and Trinity bays, Newfoundland. Although Early and Medial Cambrian faunas have been known to be present on St. Mary's and Fortune bays and have recently been found on Placentia Bay, this is the first discovery of Late Cambrian faunas on the southern coast of Newfoundland. The faunas include *Peltura scarabaeoides, Olenus truncatus, Lingulella lepis,* and new forms of *Agnostus, Obolus,* and *Lingulella.*

* Published with permission of the Chief, Illinois State Geological Survey.

NEW UPPER CAMBRIAN FORMATIONS IN NORTHWESTERN VERMONT

BY B. F. HOWELL

Recent field and laboratory studies have demonstrated that the beds holding *Bovicornellum vermontense* and other fossils in northwestern Vermont, which have heretofore been considered to form the lower part of the Hungerford formation, are somewhat older than the typical Hungerford beds and fauna and that the *Bovicornellum* beds are, in the area just south of the gorge of Hungerford Brook, separated from those of the Hungerford formation by a disconformity and an overlying sandstone, which is, itself, distinct lithologically from the overlying shales of the Hungerford formation. The *Bovicornellum* beds are therefore named the Skeels Corners formation, and the overlying sandstone is named the Saxe Brook formation. The former, a dark gray shale, is typically exposed west of Skeels Corners and is known to extend northward to a point northwest of Highgate Center and southward to the vicinity of West Georgia. The latter, a sandy dolomite (in part a dolomitic sandstone), is best exposed in Carter Hill, on the eastern side of the valley of Saxe Brook, northwest of Highgate Falls, and is known to extend several miles northeastward and southwestward of Highgate. The Skeels Corners formation contains, in addition to *Bovicornellum vermontense*, trilobites which indicate that it is very late Menevian (very late Medial Cambrian) or very early Dresbachian (very early Late Cambrian) in age. No fossils have been found in the Saxe Brook formation. The writer is indebted to Christina Lochman for advice about the age of the Skeels Corners fauna.

REVISED UPPER CAMBRIAN SUCCESSION OF NORTHWESTERN VERMONT

BY B. F. HOWELL

When Schuchert published his *Cambrian and Ordovican of northwestern Vermont* (1937) lack of paleontological evidence prevented exact correlations between the Upper Cambrian formations of the section at Highgate Falls and those of the sections exposed farther south. Recent field work and the discovery of additional fossils now make such correlations possible and permit the determination of the Late Cambrian faunal succession of the region. The succession of known or possible Upper Cambrian formations and faunas in the area between Highgate Falls and St. Albans is now believed to be as follows:

(Highgate formation, Tremadocian, Early Ordovician—Tremadocian faunas)

Disconformity

Gorge formation, Trempealeauan—Trempealeauan faunas

Disconformity

Rockledge formation, Medial Dresbachian—Late *Cedaria* or early *Crepicephalus* fauna

Disconformity

Hungerford formation, Early Dresbachian—Early *Cedaria* fauna
Saxe Brook formation, Early Dresbachian?—No fauna known

Disconformity

Skeels Corners formation, exact age undetermined—Very late Menevian or very early Dresbachian fauna, including *Bovicornellum vermontense*
Mill River formation, exact age undetermined—Contains pebbles of the underlying St. Albans formation

Disconformity

(St. Albans formation, late Menevian, late Medial Cambrian—*Centropleura vermontensis* fauna)

This is one of the most important sections of Upper Cambrian rocks in eastern North America, not only because of the large number of formations and faunas present, but because several of the faunas resemble in part faunas found in the upper Mississippi Valley and the Rocky Mountains.

NEW CRINOID FAUNA FROM THE PITKIN LIMESTONE OF NORTHEASTERN OKLAHOMA

BY LOWELL R. LAUDON

Excellently preserved fossil crinoids have been collected at many localities throughout northeastern Oklahoma from a dense lithographic limestone member that lies near the middle of the Pitkin limestone. The present collection contains ten species distributed among seven genera. Fragmentary material contains a considerable number of other species whose diagnostic characters cannot be completely determined. The fauna contains two species of *Pachylocrinus,* one of which is new, one species of *Abrotocrinus,* one new genus and species derived from *Culmicrinus,* one species of *Decadocrinus,* three species of *Scytalocrinus,* two of which are new, one new species of *Phanocrinus,* and one species of *Catillocrinus.*

STRATIGRAPHY OF THE LAKE VALLEY FORMATION OF NEW MEXICO

BY LOWELL R. LAUDON AND ARTHUR L. BOWSHER

The Lake Valley formation of southwestern New Mexico contains a large highly diversified crinoid fauna. In preparation for a detailed study of this crinoid fauna, it has been found necessary to work out the general stratigraphy of the formation. Accordingly, sections have been measured throughout the area of exposure in New Mexico. The formation has been divided on the basis of lithology and fauna into four easily recognizable members. Sections have been studied in the Sacramento, San Andres, Sierra Caballos, Mimbres, and Cooks ranges. The thickest section is found in the Sacramento Mountains and measures over 500 feet. The basal member carries an early Osage fauna among which a large number of Kinderhook species still persist. The two middle members carry faunas very similar to that of the St. Joe limestone of the Ozark region. The fauna of the upper member carries species characteristic of Burlington times. The large crinoid fauna found at Lake Valley occurs in the third member above the base. Very large crinoidal bioherms are spectacularly developed in the upper member and occasionally in the second member above the base.

LAMBEOCERAS LAMBEI FROM GARSON, MANITOBA

BY EDWARD LEITH

A very large specimen of *Lambeoceras lambei* (Whiteaves) measuring 1155 millimeters (45.5 inches) in length and, for the first time, the lines of growth and hyponomic sinus of *Lambeoceras* Foerste are described. The siphuncle of *Lambeoceras,* according to the generic diagnosis by Foerste, contains no calcareous deposits. Many specimens, however, of the genotype species *L. lambei* found recently near the type locality in Manitoba have the characteristic structures and calcareous deposits of an actinoceroid siphuncle, and these deposits are shown to be similar to those described by Troedsson for the Greenland species of *Lambeoceras.* The writer agrees with Teichert that *Lambeoceras* is a cyrtochoanite rather than an orthochoanite as suggested by Troedsson.

SOME MIDDLE CARBONIFEROUS AMMONOIDS AND THEIR STRATIGRAPHICAL SIGNIFICANCE

BY A. K. MILLER AND W. M. FURNISH

Collections of ammonoids from eastern Kentucky, northern Georgia, and eastern Nevada have recently become available for study. Those from Kentucky include representatives of the genera *Neoglyphioceras, Goniatites* s. s., *Girtyoceras,* and *Dimorphoceras;* from Georgia *Girtyoceras* and a new genus closely related to *Neoglyphioceras;* and from Nevada *Anthracoceras?* and *Cravenoceras.* Comparisons with related faunas known from Texas and Oklahoma and with European ammonoid zones indicate that the Kentucky and Georgia faunas under consideration are Meramec or Upper Viséan in age and that the Nevada fauna is probably Chester or Lower Namurian in age. The relationship between European Middle Carboniferous faunal zones and equivalent ammonoid-bearing beds in America is elucidated by means of a chart.

NEW CRINOIDS FROM UPPER PENNSYLVANIAN AND LOWER PERMIAN ROCKS OF OKLAHOMA, KANSAS, AND NEBRASKA

BY RAYMOND C. MOORE

Only 11 species of crinoids, representing 8 genera, have been described from Upper Pennsylvanian (Virgil series) beds in North America, and two species, representing two genera, are reported from Lower Permian rocks of the northern Mid-continent region. Particularly as a result of discovery of a rich crinoid assemblage in uppermost Pennsylvanian strata in Osage County, northern Oklahoma, but including several other finds, 22 new species are here reported, and two new interesting genera are described. Attention is specially directed to structures that indicate evolutionary trends. Knowledge of the Upper Carboniferous and Lower Permian crinoid faunas of North America is important because it contributes to filling a gap between the prolific Lower Carboniferous crinoid assemblage known on this continent and Europe and the similarly rich Permian fauna of Timor.

PALEOZOIC PELECYPODS *MYALINA* AND *NAIADITES*

BY NORMAN D. NEWELL

When the genera *Myalina* De Koninck and *Naiadites* Dawson were first established type species were not designated. As commonly happens the original concept of these genera is at variance with the characters of subsequently designated genolectotypes. In the present study the holotype of the type species of *Myalina* has been examined and found to be quite different from the current concept of De Koninck's *Myalina.* Typical material of *Naiadites* reveals very close resemblance to *Myalina.* Nevertheless continued recognition of both genera seems to be practicable.

SCLEROTIC RING IN THE SKULL OF *LAMBEOSAURUS*

BY LORIS S. RUSSELL

A skull of *Lambeosaurus lambei* from the Belly River beds of the Red Deer River valley, Alberta, reveals the structure of the sclerotic ring. This consists of 16 plates, arranged in a system of 4 quadrants. The uppermost and lowermost plates each overlap both of their adjacent plates, while the most anterior and most posterior plates are each overlapped by their two adjacent plates. The arrangement is the same as in *Struthiomimus samueli* and quite different from that described for *Saurolophus maximus.*

PRACTICAL APPLICATIONS OF PALEOECOLOGY IN THE STUDY OF CENOZOIC MAMMALS

BY C. BERTRAND SCHULTZ AND THOMPSON M. STOUT

The same limiting environmental factors of importance in modern ecology are of value in the study of fossil vertebrates. Certain early Pleistocene deposits near Broadwater, Nebraska, reveal interesting faunal variations between fresh-water, swampy, and upland facies; their vertebrate assemblages are quite distinct, but few forms are common. Such differences within a fauna are expectable, but their importance in correlation studies is often not fully realized. The usual "fauna" from a given area emphasizes the animals peculiar to the sedimentary environment and includes only rarely the forms of contemporaneous adjacent local habitats. Middle Pleistocene deposits near Hay Springs, Nebraska, indicate similar relationships between fauna and probable environment. Late Pleistocene loess deposits of Nebraska reveal an abundant upland life during the time of the humid *Citellus* zone, but scarcely any record is preserved of the upland animals which lived during the main (probably arid) episodes of volcanic ash and loess deposition.

In the Tertiary deposits of Nebraska, sedimentary, lithologic, and paleobotanical studies tend to confirm evidence furnished by the vertebrate assemblages as to the importance of the environment in the distribution of contemporaneous animals. Detailed stratigraphic study of the lower Oligocene (Chadron) in Nebraska suggests a marked correlation between the time of extinction of the titanotheres and periods of pronounced drouth. In the upper Oligocene, upland assemblages of animals predominate in massive clays, while probable fresh-water types are found adjacent to and in channel deposits. Miocene and Pliocene deposits also offer many interesting examples of variations in the distribution of contemporaneous animals between fresh-water, upland, and even lacustrine environments.

ONTOGENY OF A PRIMITIVE ACIDASPID

BY MARK H. SECRIST AND ROBERT R. WHEELER

The genus *Onchaspis* was erected for primitive acidaspids of *Ceratocephala* affinities and has been represented by the cranidium of a single species, *Onchaspis confraga*. Description of a new species, *Onchaspis nuchampliata*, from the Chazy, based entirely upon growth stages, offers much new data on the genus and its relation to other acidaspids.

Comparisons of the numerous excellently preserved trilobite parts show certain progressive trends of growth. While features of generic importance remain constant, specific ones develop consistently toward deducible end stages. Also observable in certain instances are variations among individuals, presumably as environmental adaptations.

Evidence assembled from ontogenetic studies and comparison with other acidaspids shows that *Onchaspis nuchampliata* is a primitive acidaspid having no described pre-Chazyan affinities and only two contemporaneous relatives. The presence of weak dorsal furrows in the smallest cranidia is a primitive feature found in no adult acidaspid. Rudimentary lateral lobation, unfused free cheeks, and absence of a meso-occipital lobe common in later forms likewise are features interesting from the viewpoint of classification that distinguish this species as an early acidaspid.

TYPES IN MODERN TAXONOMY

BY GEORGE GAYLORD SIMPSON

The common idea of types in zoology and paleontology has been that they are specified items, specimens, and species that serve (1) As the basis for defining

taxonomic units, (2) as standards of comparison for those units, and (3) as fixed points within the units with which names are associated. Modern taxonomy involves the theory of sampling and seeks to draw inferences regarding natural populations from samples. In such work, the same items cannot properly serve all three of the supposed purposes of types.

The basis for definition and inference and the standard of comparison should include all the specimens referred to the species by a given author at any time, whether in the original description or subsequently. All such specimens, whenever found, whenever described, and by whomsoever, are of equal value for this purpose. The usual concepts of "primary types", "secondary types", or even of "types" are inapplicable or imply and promote incorrect methods. Such a group of specimens may be called a hypodigm.

The term "type" may be confined to the fixed, name-bearing items within the various fluctuating hypodigms. Most of the dozens of names that have been suggested for type terminology are useless or worse and should be discarded. The terms "type", "syntype", "lectotype", and "neotype" are probably adequate for any real and proper purpose.

The hypodigms of superspecific units are also groups of concrete specimens although their types are abstract concepts.

CONODONTS FROM THE DEVONIAN AND ASSOCIATED CLAYS OF MINNESOTA

BY CLINTON R. STAUFFER

Conodonts occur in the shaly partings of the Cedar Valley limestone in southern Minnesota. Similar conodonts also occur in the clays above the same limestone in the vicinity of Austin, Minnesota. These latter, however, are mingled with others of undoubted Ordovician origin, and hence it seems certain that the fauna of this clay deposit has had a dual origin. A number of new species are described from these several horizons.

TWO TEXAS PALEOZOIC ARTHROPODS

BY F. E. TURNER

Two arthropods from the Paleozoic of the Marathon region of west Texas are discussed. One is a trilobite with a long anterior spine and widely flaring lateral spines, found in the Monument Springs dolomite, generally regarded as Beekmantown in age. The other is an insect or possibly a crustacean of affinities as yet undetermined, which was collected in the Tesnus formation generally regarded as Pennsylvanian in age.

TYPE OF *PLESIOSAURUS LONGIROSTRIS* BLAKE AND THE CLASSIFICATION OF THE PLESIOSAURS

BY THEODORE E. WHITE

The holotype of *Plesiosaurus longirostris* Blake, which has been missing for many years, is refigured and redescribed and is allocated to its proper position in the order. The previous classifications and the characters upon which they are based are discussed. A new grouping of the genera, based upon the characters emphasized by Seeley, Williston, and Watson, is proposed.

LOWER MIOCENE LAND MAMMALS OF NEW JERSEY

BY HORACE ELMER WOOD, 2D

The Tertiary land mammal fauna from near Farmingdale, Monmouth County, New Jersey, is known only from Marsh's preliminary description. Restudy gives the

following identifications: *Diceratherium matutinum* (near *D. armatum*), *D.* cf. *cooki*, *Ammodon leidyanus* (near but advanced beyond *Dinohyus hollandi*), *Desmathyus antiquus* (near but advanced over *D. pinensis*). This faunal assemblage, apparently from the base of the Miocene Kirkwood formation, compares closely with the lower Miocene of the Great Plains and must be either of Harrison age or slightly younger.

DID VERTEBRATES MAKE THE TRAILS *KOUPHICHNIUM* (JURASSIC) AND *MICRICHNUS* (TRIASSIC)?

BY KENNETH E. CASTER

Heteropodous trails from the Mesozoic rocks of Europe and North America which have been consistently attributed to vertebrates appear, upon detailed study in the light of modern invertebrate ichnology, to have been made by horseshoe crabs. *Kouphichnium* of the Jurassic lithographic limestone of Bavaria has been assigned since its original description (1862) to a variety of diminutive vertebrates: pro-avian, *Archeopteryx,* pterodactyl, mammal, and dinosaur (*Ornitholestes*). A bipedal vertebrate has been required to explain the heteropody. Limuloid trails, as the writer showed in 1938, are heteropodous and of similar dimensions. Possibly the fact that the trail has been consistently interpreted in what now appears to be a reversed direction of walking has tended to obscure the problem. *Micrichnus* trails of the Triassic red beds of eastern United States are similar to *Kouphichnium* and have likewise been attributed to vertebrates, preferably tiny dinosaurs. These trails seem also to have been interpreted in reverse, and when properly oriented are likewise assignable to a xiphosuran. This interpretation of *Micrichnus* would tend to support the evidence of local estuarine facies in the Newark beds presented by Bryant's (1934) elasmobranch fauna from Pennsylvania.

RADIOLARIAN FAUNAS FROM THE EOCENE NORTH OF MOUNT DIABLO, CALIFORNIA

BY BRUCE L. CLARK AND ARTHUR CAMPBELL

Radiolaria were obtained from two distinct zones in the Eocene north of Mount Diablo. A brief discussion is given in this paper of the probable ecological conditions that existed at the time these deposits were laid down, and a description of the method of preparing material will be given, together with lantern slides illustrating some of the most important species. (Geological Society Project.)

TERTIARY AND PLEISTOCENE MAMMAL AND BIRD TRACKS IN DEATH VALLEY

BY H. DONALD CURRY *

At several widely separated localities in Death Valley National Monument, California, numerous fossil mammal and bird tracks have been discovered in the last 2 years.

From stratigraphic relationships and certain aspects of the fauna, an occurrence found in the Salt Creek Hills in central Death Valley is considered Pleistocene. These ichnites represent camel, horse, several types of wading birds, and possibly a probocidean.

While their correlations are in doubt, all the other occurrences are late Tertiary. The most important of these areas is in the central portion of the Black Mountains, where ichnites are widely distributed through several hundred feet of folded playa sediments. They occur both as original imprints and as molds and, when not too long exposed to weathering, are remarkably preserved. The chief element in the large fauna represented is that of artiodactyls of many sizes and kinds, including several camels and a member of antilocaprine and deer-like forms. There are several

* Introduced by Chester Stock.

distinct types of carnivores and at least three sizes of supposedly monodactyl horses. Bird tracks are numerous and vary in size and shape; and even small lizard and rodent tracks have been recognized. Some anomalous imprints, both large and small, have yet to be identified.

No fossil bone has been found, and, owing to the limitations inherent in the study of ichnites and the lack of comparative material, accurate age and faunal determinations are necessarily difficult.

UPPER MIOCENE FISHES FROM THE SANTA MONICA MOUNTAINS, CALIFORNIA

BY LORE R. DAVID *

Collections of fish fossils have been made at three different localities on the west side of Sepulveda Canyon, Santa Monica Mountains, California. The fishes occur in siliceous sandstones and shale of the Modelo formation (Upper Miocene). The assemblage, though small in number (about 55 specimens), shows a great variety of forms and represents 13 families with 18 genera. With exception of the Elephenoridae and Halosauridae, all the families that have been identified exist now along the Pacific Coast. Five genera are regarded as still living, and two others are very close to existing genera. Eleven genera are extinct.

The fossil fishes suggest a marine subtropical fauna living relatively close to shore. Fossilization did not occur in very shallow water. The presence of deeper-water fishes (Halosauridae, Zaproridae, *Auxides*), probably a pelagic type, suggests occurrence of deeper water.

The fauna is principally of eastern origin. Mixed with these elements are a few (*Sebastodes, Arnoldites, Araeosteus*) of northern and Pacific origin. Only one family (Elephenoridae) suggests a relationship between the California fauna and that of Japan. The Modelo fauna is related to that described by the late Professor Jordan from Lompoc. Of the 18 genera now recognized 8 are known from Lompoc and likewise 7 species are either identical with or closely related to fishes described from Lompoc. (Geological Society Project.)

NEW *TYPHIS* FROM THE CALIFORNIA MIOCENE

BY A. MYRA KEEN

A specimen of the muricid gastropod *Typhis,* collected by Donald C. Birch, of Bakersfield, California, from the Round Mountain shale (Temblor) of the Kern River district proves not only to be a new species but also to be a representative of a subgenus, *Talityphis,* not previously recorded from the Tertiary of California. A fragmentary specimen later found by Robert T. White at the same locality (near the center of the S. W. ¼ sec. 6, T. 29 S., R. 30 E., M. D. B. and M.) confirms the allocation. The species bears a striking resemblance to *Typhis* (*Talityphis*) *alatus obesus* Gabb of the Antillean Gatun formation. Other species in the same Temblor fauna, notably certain *Clementia, Acila, Terebra,* and *Cancellaria,* reinforce the implication that the Round Mountain shale of the Kern River region is to be correlated with beds of Gatun age in Central America and the Caribbean basin. In the stage terminology of the California Miocene, the Round Mountain shale is probably upper Saucesian or possibly lower Relizian. The Gatun has been correlated by Vaughan (1924) with the Helvetian of the European column.

* Introduced by Chester Stock

AVIAN FOSSILS FROM THE LOWER MIOCENE OF SOUTH DAKOTA

BY ALDEN H. MILLER *

Flint Hill quarry, Rosebud formation, of the Lower Miocene in South Dakota, has yielded a surprisingly large number of bird bones. At least eight genera are represented, four of which are new. *Strix dakota,* an owl, is the earliest known representative of its family in North America and the only representative of its order between the Eocene and Pleistocene. A large anserine, *Paranyroca magna,* represents a new family. An additional Old World vulture is recorded for this continent. Other new species belong to the orders Anseriformes and Galliformes. Study of the avifauna further confirms the view that evolutionary change in birds in the latter part of the Tertiary has been much less rapid than in mammals. Families and distinctive adaptive types of birds, in general, have persisted with little fundamental modification since the Miocene.

KHIRTHAR NUMMULITES FROM SOUTHEASTERN IRAN†

BY HUBERT G. SCHENCK

During explorations in Iran in 1937, H. Hotchkiss, H. Afshar, and the writer measured by plane-table an Eocene section in the mountains at lat. 29° 50′± North, long. 59° 55′± East (Greenwich) on a road from Zahidan to Bam. Distinctive Khirthar (Middle Eocene) nummulites and other Foraminifera were allocated in the section, and the identifications of some of the material were verified by L. M. Davies. At one locality were abundant specimens of a species often identified as *"Nummulites perforatus."* This species occurs below a thickness of 2000± feet of apparently unfossiliferous Eocene beds. No strictly Upper Eocene marine fossils were found in this district nor elsewhere in eastern and northern Iran. Comparisons of this section with others measured in the Elburz Mountains suggest that the much discussed "green-beds" are not Oligocene but Eocene.

REGIONAL SIGNIFICANCE OF THE GAVIOTA FORAMINIFERA OF CALIFORNIA

BY HUBERT G. SCHENCK AND ROBERT M. KLEINPELL

A previous report gave the provisional results of a study of the Foraminifera from the Gaviota formation at its type area in western Santa Barbara County, California. Recently, through the cooperation of many colleagues, assemblages from several carefully measured and sampled surface and subsurface sections in Washington, Oregon, and California were studied. These assemblages are relatively constant in their qualitative composition and biostratigraphic occurrences throughout a distance of about 850 miles along the Pacific Slope of North America.

CARNIVORA IN THE HEMPHILL MIDDLE PLIOCENE OF TEXAS

BY R. A. STIRTON

Carnivore remains are abundant in the Hemphill fauna. *Osteoborus,* the hyaenoid dog, and *Machairodus,* the sabre-tooth cat, are represented by series of skull and skeletal elements. A good knowledge of species variation in these genera can be gained from the series. Other genera, known from fewer specimens, are *Agriotherium, Plesiogulo, Taxidea,* and *Vulpes.*

Osteoborus, Agriotherium, and *Machairodus* display osteological characters which indicate excellent adaptation to the plains environment in which they lived.

* Introduced by R. A. Stirton.
† Presented with permission of the Amiranian Oil Company.

NEW EVIDENCE AS TO THE AGE OF THE CUYAMA BEDS, CALIFORNIA

BY V. L. VANDERHOOF

The land-laid Cuyama Beds of Ventura County, California, have been called Monterey Miocene by Gazin, who in 1930 described a small vertebrate fauna from there and judged it to be equivalent in age to the Mint Canyon and Barstow. His age determination was based upon the horses *Merychippus* and *Protohippus*. In 1939, *Pliohippus tantalus* was found at the Cuyama locality. This genus has never been found below the Pliocene, and the species is identical with that from the Ricardo. From this, we may conclude that the Cuyama Beds are not "Monterey" nor even Miocene, but represent the lowest Pliocene, a conclusion in agreement with A. E. Wood's studies of the Cuyama rodents.

PLESIOSAUR FROM THE UPPER CRETACEOUS OF THE SAN JOAQUIN VALLEY

BY SAMUEL P. WELLES

This giant marine reptile was found by a student at Fresno State College and collected by a joint party from Fresno and the University of California Museum of Paleontology. Recently prepared mainly by the workers on the Museum's W.P.A. project the specimen proves to be a long-necked, short-headed sauropterygian of the family Elasmosauridae.

The skeleton is nearly complete, lacking only parts of the skull, shoulder girdle, and paddles. On the basis of this skeleton it is possible to suggest several revisions of the taxonomy of the North American plesiosaurs and to corroborate the Upper Cretaceous age of the Moreno formation.

PALEOCENE MOLLUSKS FROM PANOCHE CREEK, CALIFORNIA

BY ROBERT T. WHITE

A large Paleocene fauna of mollusks, corals, and brachiopods has been collected from a road cut on the Panoche Pass road opposite the confluence of Silver and Panoche creeks, Fresno County, California. These fossils occur in the lower 15 feet of the Lodo formation. Many of the species are common to the lower part of the type Martinez formation on the northeast flank of the Pacheco syncline, Contra Costa County, California. A few of the species present at both localities are: *Turritella infragranulata* Gabb, *Brachysphingus gabbi* Stewart, *Cucullaea mathewsonii* Gabb, *Glycymeris major* (Stanton), and *Trochocyathus zitteli* Merriam. In addition there are several new species, among which are a *Venericardia*, a *Turritella*, and a *"Surculites."*

The excellent preservation of the specimens in a soft fine-grained micaceous sand has made it possible for the first time to expose for study and photographing the interiors of *Cucullaea mathewsonii* and other pelecypods. Also, many specimens of *Glycymeris*, *Turritella*, and *Brachysphingus* offer an opportunity for a study of variation.

ABSTRACTS OF SECTION E, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

DECEMBER MEETING AT COLUMBUS

SILURIAN LITHOLOGY IN WESTERN TENNESSEE AND IN ADJACENT STATES

BY JOHN R. BALL

This paper presents a brief discussion of Silurian lithology in parts of western Tennessee and in certain of the adjacent States. Distinctive Silurian rock units are readily recognized in western Tennessee. They have been assembled in several formations and members by geologists. In southeast Missouri the Niagaran strata have been regarded, hitherto, as a homogeneous sequence.

In this paper emphasis is not given to stratigraphy and correlations as much as to general lithologic similarities in the regions considered. Detailed comparisons are made for western Tennessee, southern Illinois, and southeast Missouri. Lithologic aspects, such as coloration, texture, earthy admixtures, presence or absence of chert, distribution of glauconite, and the development of oölite, are considered. The persistence of certain beds and of fossil horizons is noted, where known. Some attention also is given to marked changes in the facies. The description and extent of these features in selected areas are presented.

MATHEMATICAL PROBLEMS IN SEISMOLOGY

BY ARCHIE BLAKE

The principal mathematical problems of instrumental seismology are to work out theories of instruments (*e.g.*, the algebra of the galvanometric seismograph) and to aid in the development of new instruments best suited to meet specific needs (seismographs capable of giving more quantitative results, strong-motion seismographs, strainmeters, rotation seismographs, and tiltmeters).

The problem of the earth's interior consists principally of the extension of elastic theory to new boundary and initial conditions, inhomogeneous and anisotropic media, and finite strain. An important advance is the method of Pekeris and Slichter, in which the variation of the density, as well as the ratios of the bulk modulus and rigidity to the density, can be obtained as a function of the depth by measuring the form of the wave on the seismogram, as well as its arrival time. Other problems are the mechanism of occurrence of deep earthquakes and the calculation of the elastic constants within the core.

The strong-motion problem is simple in conception: To study the response expected of various kinds of structure to earthquakes, with a view to obtaining data for earthquake-resistant design. Complexities and mathematical problems enter in designing instruments to measure ground motion, reducing the records obtained, and taking account of interactions among the modes of oscillation, finite strain, and yielding of the ground. A comparatively new branch—statistical seismology—opens up a wide variety of mathematical problems.

Finally, there is a need for new calculating machines to lighten the labors of seismologists and workers in other fields and encourage them to undertake calculations which they now evade.

POSSIBILITY OF AN ADDITIONAL METEORITE CRATER NEAR ODESSA, TEXAS

BY JOHN D. BOON AND CLAUDE C. ALBRITTON, JR.

In the vicinity of Odessa meteorite crater are a number of sinks which, viewed from the air, closely resemble the crater in plan and general configuration. It is

suggested that at least one of these sinks may be a meteorite crater modified, since the time of its formation, by the solvent action of ground water on the underlying bedrock.

Several meteorite fragments, the largest of which weighed 1.3 grams, were found around a sink located approximately 1.3 miles southwest of the crater. This sink is about the same size as Odessa crater, but unlike the crater it does not have a rim about it. Moreover, the drainage around the margin of Odessa crater is centrifugal, whereas that around the sink is centripetal.

Preservation of rims about meteorite craters in the Odessa region, or any other area characterized by abundant sinks, would depend largely upon the location of the craters. If a crater were formed in an area of centrifugal drainage the rim would persist longer than if the crater were formed in an area of centripetal drainage. In the latter instance both the rim and associated meteoritic iron might soon be covered with wash, and the decomposition of buried meteorites would be hastened. The sink in question may therefore be a modified meteorite crater.

STRATIGRAPHIC REVISION OF THE UPPER NIAGARAN DOLOMITES OF WEST-CENTRAL OHIO AND ADJACENT NORTHERN INDIANA

BY DANIEL A. BUSCH

The upper Niagaran dolomites of west-central Ohio formerly included the Euphemia-Springfield-Cedarville sequence. Two additional formations, whose names were taken from the upper Niagaran of northern Indiana, are now known to extend into west-central Ohio, namely, the Huntington (restricted) dolomite and the New Corydon limestone. In this study the status of the Euphemia and Springfield formations remains unchanged.

The Huntington (restricted) represents that portion of the Huntington formation of northern Indiana which contains a Guelph fauna. The lower 43 feet of the 70-foot section of Huntington dolomite, as exposed at Ridgeville, Randolph County, Indiana, is thus relegated to the underlying Cedarville formation whose total thickness is 95 feet. Fifteen of the 166 identified species from the Huntington (restricted) formation strongly indicate an early Guelph age for this formation. That the Huntington (restricted) is older than the Peebles of southern Ohio and the true Guelph of northern Ohio and Ontario is indicated by the presence of many species common in the underlying Cedarville formation and a similar number of different forms abundant in the typical Guelph.

The overlying New Corydon formation has been traced into western Ohio and contains an impoverished Huntington (restricted) fauna, rather than a recurrent Lockport fauna as was suggested by earlier writers. Its fauna, likewise, antedates that of the true Guelph.

SOME BIOLOGICAL CONSIDERATIONS IN INTERPRETING THE STRATIGRAPHY OF THE PENN-YORK EMBAYMENT

BY KENNETH E. CASTER

Comprehensive facieology has proved to be the key to the stratigraphy of the Upper Devonian and basal Mississippian of the Penn-York Embayment. The paleontological aspects of facies interpretation are apparently in need of some clarification when, on facieological grounds, certain sections in western Pennsylvania have been interpreted as being equivalent to the Dunkird formation by some workers and equivalent to the Conewango by others. There is a homofacial difference of several hundred feet involved. Some aspects of the biological basis for this disparity will

be considered, and some of the seeming dangers of traditional stratigraphic methods, when applied to this area, will be briefly discussed. Principles, rather than matters of specific taxonomy or localized correlation, seem to be subjects meriting serious consideration at this time.

PROBLEM METHOD IN ELEMENTARY INSTRUCTION

BY R. F. COLLINS AND H. A. MEYERHOFF

Beginning courses in geology present a pedagogical problem too commonly "solved" by rigidly standardized lectures, laboratory outlines, and examinations. Courses thus standardized are markedly effective in blighting student and instructor interest and are open to the suspicion of failing to attain the college level of intellectual discipline.

Twelve years' experience has demonstrated the success of problem methods in laboratory instruction and problem type examinations; genuine student interest is aroused, and staff ennui is eliminated. Further, mentally sluggish students hesitate to enroll in a science department where spot thinking is required. A possible sequel is the registration of 45 per cent of first year students in second year courses.

Measured by ground covered in class hours, the problem system is less efficient; when judged by retained student learning, the problem system is, in the authors' opinion, definitely superior.

LAND USE AND FLOOD CONTROL

BY J. S. CUTLER

Soil conservation through proper land use, together with suitable erosion control and fertility practices, is popular today. Flood protection by engineering works, such as great reservoir and levee systems, is in great demand. The two problems, soil conservation and flood control, are definitely related. The latest development in agriculture is the planning of improved land use, together with agricultural engineering measures on the watersheds of flood-source areas, in conjunction with reservoir and levee systems for flood control.

The object of this paper is to discuss the approach to planning land use and related measures on a watershed basis toward flood control, as being carried out by the United States Department of Agriculture. The methods employed by the party engaged in a flood control survey on the Muskingum River Watershed in eastern Ohio are cited as specific examples.

In considering a flood-source watershed, the first step is to analyze the streamflow characteristics and watershed runoff relationships under present land use and conditions. Soil infiltration rates and the effect of cover on the water-holding capacity of the soil are studied. Technical plans are made for improved land use, including erosion control and other measures for reducing and retarding runoff. Based upon climatic records, types or design storms are selected; and, by using the rainfall-distribution-graph method, runoff is computed for the improved land use conditions and supporting practices as included in the technical plan. The reductions in flood crests and soil erosion effected by the plan are measured in terms of reduced flood damages and benefits to the land respectively.

ELEMENTARY GEOLOGY AS PRESENTED AT NORTHWESTERN UNIVERSITY

BY E. C. DAPPLES AND W. E. POWERS

Elementary geology is designed primarily for students who desire a broad survey course, to provide a physical background for students of geography, and to serve as

a basic course for those who will take more geology. Each student registers for two lectures, one laboratory, and one quiz class per week. One and one-half days of field work per semester is required. The first semester physiography, weather and climate, and mineralogy are considered; the second semester volcanism and structural and historical geology.

Lectures are formal units delivered chiefly by two instructors each of whom presents subjects allied with his field of interest. Other staff members are invited to present one lecture each to serve as a means of acquainting the students with other instructors. The system of rotating lecturer has been effective in: (1) Reducing the number of lecture sections from eight groups to four groups. Four lecture sections are maintained because of limited seating capacity. (2) Developing a formal lecture in which one subject is concluded at the close of each session. (3) Preventing the instructor from dwelling over certain fields at the expense of others. (4) Providing the student with the viewpoint of more than one instructor.

Quiz sections in small groups meet for a written examination and directed discussion. Laboratory consists of one 2-hour session which is considered preferable to two meetings weekly. Exercises are based on selected topographic and geologic maps and folios. Because of limited rock outcrops near the campus, field work presents a problem, which is partly solved by trips to localities 200 miles distant. Local trips are suitable for physiographic study.

SUBSURFACE STRATIGRAPHY OF WESTERN PENNSYLVANIA

BY CHAS. R. FETTKE

Throughout northwestern Pennsylvania, wherever it has been penetrated by the drill, the Medina formation (restricted) retains the characteristics of the western New York section. The gray Whirlpool sandstone and red Grimsby members are well developed, and in places the Thorold sandstone is present at the top. The Rochester shale member of the Clinton group becomes more calcareous. The Lockport dolomite, considerably thicker than at its type locality, is present. The Salina formation under western Pennsylvania retains many of the characteristics exhibited in central and western New York. Beds of anhydrite and salt are present at least as far east as eastern Tioga, Jefferson, and Westmoreland counties. Upper Silurian dolomitic limestone probably overlies the Salina formation proper. It is difficult to draw the line between the uppermost Silurian limestones and the base of the Helderberg group from sample studies. The former usually is dolomitic and nonfossiliferous, and anhydrite appears a short distance below its top. The limestones of the Helderberg group are nonmagnesian, in part cherty, and frequently very fossiliferous. The Ridgely sandstone member of the Oriskany group underlies all of Pennsylvania west of the Allegheny front except two areas, one marginal and the other within the main area of deposition. Whether or not the Shriver member is present has not been established definitely. The Onondaga limestone occurs throughout the area. It becomes increasingly cherty to the south until portions of it consist entirely of chert. The Tully limestone at the base of the Upper Devonian has proved to be an excellent key horizon throughout most of western Pennsylvania. In north-central Pennsylvania the top of the Devonian is placed at the base of the Knapp formation and in western Pennsylvania at the base of the Berea-Corry horizon. The latter horizon has not been tied in definitely with the base of the Pocono group along the Allegheny front, and the Mississippian-Devonian boundary, therefore, is placed tentatively at the top of the Catskill red beds in the eastern part of the area

under discussion. In Venango County at Franklin 125 feet of dark reddish-brown to purplish-gray shale immediately overlying the Venango First sand and 60 feet below the Berea-Corry sandstone probably represents the horizon of the Bedford shale of Ohio.

BY-PRODUCT MINING OF COMPLEX FELDSPAR DIKES

BY B. C. FREEMAN

Two beryl pegmatite dikes occur in Lyndoch township in southeastern Ontario. The chief constituents are feldspar and quartz, accompanied by tourmaline, fluorite, garnets, monazite, columbite, and lyndochite.

The successful mining of such deposits presents major difficulties. Transportation facilities are poor. The beryl is in large crystals, some of them giant-sized, and the distribution is erratic. Sampling is almost impossible, and no ore body can be blocked out. Financially disastrous attempts have been made to mine these deposits for beryl alone.

Some of the feldspar is suitable for ceramic uses and can be mined profitably if costs can be kept low enough. Columbite and lyndochite are ore minerals of columbium and tantalum. The suggestion has been made that the constituents other than feldspar can be stored until a stock pile, large enough to be sold, is accumulated. There are hazards in this procedure. Selective mining of the materials is easy, but successful marketing of the various products is hard. Beryl, for example, does not have an established market price and a ready sale. Also, stock piles are frozen assets.

The prospective operator cannot safely assign a definite value to such minerals as beryl and columbite in his preliminary estimates. He should regard them as special impurities and the money realized from their sale as a windfall.

EROSIONAL DEVELOPMENT OF WESTERN WEST VIRGINIA

BY HARRY M. FRIDLEY

It is generally agreed among geomorphologists that the upland surface of western West Virginia and adjacent States has been lowered from the Schooley peneplane. Recently it has been postulated that this lowering has been accomplished without approaching baselevel at any time. Had the present surface been reduced as much as 500 or 1000 feet without peneplanation the valleys of the large streams, such as the Monongahela and New rivers, would be much wider than they are at present. These streams are actually entrenched below an upland of accordant summits. The Monongahela, in particular, is flowing in distinct entrenched meanders. If the present upland surface has been lowered from the Schooley peneplane to a level at which, at one time, streams were allowed to meander over the landscape without regard to structure, the surface at that time was actually a peneplane. Since it is extremely difficult if not impossible to correlate this erosional level with any recognized peneplane east of the Appalachian ridges, it should have a local name. Therefore, it has been given the appropriate name of Allegheny peneplane.

USE OF MATHEMATICS IN THE DELINEATION OF MAGNETIC AND ELECTRIC ANOMALIES

BY LACHLAN GILCHRIST

There appear to be two classes of magnetic anomalies:

(a) Those due to a difference of permeability of the Earth's field in masses of homogeneous materials. In this case Z, the vertical component of the Earth's

field at a point in the meridian plane directly above a massive body of material of rectangular section, is given by the formula:

$$Z = \frac{C V_E}{R^3 (x \sin\alpha + d \cos\alpha)^2} (R^2 \cos\alpha (x + R \cos\alpha) + xd(x \sin\alpha + d \cos\alpha),$$

where d is the distance from the origin to the top of the body,
x is the coordinate perpendicular to d
$R^2 = x^2 + d^2$
α = angle of dip
C = constant

(b) Those in which a large but finite number of consequent poles are to be found in the material and for which there is a resultant equivalent magnet in the form of a rectangular parallelopiped. The formula representing this case is definite but somewhat cumbersome.

Two sets of difficulties are encountered in electric anomalies:

(a) Since the equation of distribution of applied potential for a steady flow in an extensive homogeneous conductor implies continuity, the location of the boundaries of anomalies can only be approximate. The condition is further complicated by the necessary dual electrode character of the application of the potential.
(b) Portions of the Earth, through which there flows an electrical current, form a "leaky condenser" of finite capacity, and therefore reactance, as well as ohmic resistance, must be taken into account.

The difficulties associated with (a) may be met partly by the following lay-outs:

(1) the central current line electrode method on the surface of the ground,
(2) a central point of application of potential at depth which is a centre of symmetry to two parallel current line electrodes of the surface of the earth.

The formula for the specific resistance of a homogeneous medium is simple and for media containing anomalies in general very complex.

The difficulties associated with (b) may be met partly by the use as comparator of a reactance-free standard resistance. The results of measurement by methods (1) and (2) will give a fair comparison of the resistivity of adjacent portions of underground heterogeneous material of not too great complexity.

BARIUM IN APPALACHIAN SALT BRINES*

BY E. T. HECK

The areal and stratigraphic distribution of barium in the salt brines of the Appalachian region is discussed and shown by means of maps.

The investigation shows that the most logical source of the barium in the brines is the mineral barite. Chemical reactions for the conversion of the relatively insoluble barite to more soluble compounds are discussed in detail.

It is pointed out that the areas most productive of oil and gas also produce the brines that are relatively the richest in barium.

IMPORTANT CONSIDERATIONS FOR THE DEVELOPMENT OF A GEOLOGY COURSE IN GENERAL EDUCATION

BY LOUIS M. HEIL

A number of geology instructors have become critical of the contribution the study of geology is making to the general education of students. The criticism involves a questioning of the assumption that an introductory course in Geology designed primarily to train geologists is also adequate or desirable for purposes of general

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education. The fact that, during the last 20 years, the proportion of "general education students" has increased has tended to precipitate the problem. What to do in a course in geology to be offered for students who will not become geologists is, therefore, the problem of many geology teachers.

The development of such a course can be guided by three important considerations: (1) The purposes of the course—that is, a clear statement of what the course is to accomplish. One purpose might be "the development of an understanding of problems dealing with the conservation of natural resources." (2) A clear indication of what the student should be able to do if the instructor is successful in achieving his purposes—that is, in the example above, the student might be expected to justify the thesis "The cutting of timber should be restricted", by citing the relevant evidence and necessary assumptions. (3) The selection of topics and problems from the field of geology which will lead to the successful achievement of the instructor's purposes. Thus, the student should be given an opportunity to justify similar theses through the give and take of discussion.

SHIFTING ECONOMIC VALUES OF ABANDONED LAKE BEDS IN OHIO

BY GEORGE D. HUBBARD

Lake beds now essentially waterless are much more surely recognized by silts and peat laid down in them than by any other feature found. Nearly a score of abandoned lake beds have been studied in the past two summers.

In the early days probably water fowl and other game were the chief values of the marshes and disappearing lakes. Barrier difficulties may have wholly offset game values.

The peat fuel value has rarely been recognized in Ohio because forests and coal were too abundant. Agriculture has claimed silt areas as strong crop lands, and for a hundred years some of the peat areas have been cultivated as onion fields and later as celery, radish, and carrot lands. As peat has oxidized, these crops have been displaced by tomatoes, peas, beans, and even corn, oats, potatoes, and wheat. The beds near Akron are now very valuable for market gardening.

Silts and clays have been dug for the manufacture of brick and tile in several lake beds, and tons of the humus have been hauled away, sold, and supplied to gardens and lawns lacking organic matter. Deltas and, in a few places, remnants of beaches have been opened for gravel and sand. The future will see the peat entirely oxidized and the underlying silts used for general and intensive agriculture.

EARLY PLEISTOCENE GLACIATION IN NORTHEASTERN KENTUCKY

BY WILLARD ROUSE JILLSON

In 1924 the writer announced the discovery of two large and widely separated erratic boulders in an area in northeastern Kentucky heretofore regarded as unglaciated. The larger, a porphyritic granite gneiss, estimated to weigh about 16 tons, was found high on a hillside at an elevation of about 925 feet about 15 miles south of the Ohio River near Epworth in western Lewis County. The smaller, a graphitic schistose quartzite estimated to weigh about 3 tons, occurred at an elevation of about 720 feet in a deep hollow about 40 miles south of the Ohio River and nearly due south of the larger, near Farmers in western Rowan County.

Both boulders are foreign to Kentucky; as their size, weight, and topographic occurrence preclude transportation by river or ice rafting, a Kansan or Nebraskan ice sheet was proposed.

Recent precise levelling fixes the Epworth boulder at 1009.3 feet above mean sea level. The top of the ridge from which it might have crept is 154 feet higher. Its maximum possible elevation on the east side of Licking River valley is 75 to 200 feet above the dividing ridge on the west side of Licking Valley. No postglacial differential warping on a north and south axis is recognized.

Evidence now in hand thus precludes transportation by ice rafting and establishes the existence of an early Pleistocene glaciation in this part of Kentucky.

GEOLOGY OF SOME RECENTLY DRILLED DEEP WELLS IN KENTUCKY

BY WILLARD ROUSE JILLSON

During the past year or two 12 important wells ranging in depth from 2000 to 5000 feet have been drilled in the course of oil and gas exploration in Kentucky. Four of these wells have been drilled considerably east of the axis of the Cincinnati arch in Estill, Lee, Wolfe, and Knox counties, four far to the west of the arch in Hopkins, Trigg, and Henderson counties, and four in central Kentucky close to or on the Ordovician geanticlinal uplift in Owen, Anderson, Casey, and Barren counties.

Each of the four wells drilled east of the Cincinnati uplift was completed in either the Lower Middle or Lower Ordovician. A predominantly silica sandstone about 10 or 12 feet thick, heretofore correlated with the Saint Peter sandstone of the Mississippi Valley, was recognized.

The four western Kentucky wells were completed in horizons ranging from the Devonian and Silurian down to the lower Ordovician, but in this area of testing the Saint Peter sandstone was not encountered, owing to absence of this stratigraphic unit in some areas and lack of drilled depth in others.

In central Kentucky on the top and high on the western flank of the Cincinnati arch the Saint Peter sandstone was not recognized, owing to absence in some locations and faulty sampling of drill cuttings in others.

This program of widely distributed deep drilling in Kentucky confirms the presence of a relatively thin sandstone unit in the lower Ordovician of eastern Kentucky which has been correlated with the Saint Peter. Small amounts of oil and gas have been found in the Ordovician.

SEISMIC ACTIVITY IN THE EASTERN UNITED STATES IN RELATION TO ZONES OF MEGASHEARING

BY ASHTON KEITH

Further studies of megashearing have taken into consideration data pertaining to nearly all important earthquakes. All items of information have been plotted on a map which shows the relations of the earthquakes to zones of megashearing. The map suggests:

(1) Practically every earthquake of which the U. S. Coast and Geodetic Survey has record had its epicenter on one or more of the zones of megashearing.

(2) The earthquakes east of the Rocky Mountains were not sporadic and isolated occurrences but occurred in series genetically related to certain active zones of megashearing.

(3) Although the periodicity of each series is different, it seems possible to predict the next seismic disturbance in each series with fair precision as to time and place.

(4) Seismic disturbances east of the Rocky Mountains and along the rectilinear megashears are apparently due to tangential stresses from the north and east.

(5) Crustal disturbances centered on arcuate megashears are due chiefly to gravity.

(6) Chronology of disturbances along rectilinear megashears indicates progressive movements toward the south and southwest.

(7) The study, though barely begun, suggests that seismic and microseismic disturbances fall into at least four principal categories.

GROUND-WATER PROBLEMS IN OHIO, WITH SPECIAL REFERENCE TO BUTLER AND HAMILTON COUNTIES *

BY FRED H. KLAER, JR.

Ground water is used by 319 of the 410 public water-supply systems in Ohio to supply about one and one-quarter million people. Many industries use large quantities of ground water for cooling and manufacturing purposes. It is estimated that the ground water used in Ohio has an annual value of more than 10 million dollars and is a natural resource whose importance is not generally realized. Considerable decline of water levels in the past decade has been reported throughout the State, especially in certain heavily industrialized areas; however, lack of accurate observations makes difficult the determination of the character, amount, and causes of the decline. An investigation of ground-water conditions in Butler and Hamilton counties by the Federal Geological Survey in co-operation with the two counties, begun in June 1938, has provided the first accurate information in regard to conditions in that part of the State. This investigation shows that in the two counties about 65 million gallons of water are daily pumped from the alluvium-filled preglacial valleys of the ancestral Ohio River, now occupied by the so-called Norwood Trough and Mill Creek, and of the Miami River. Great decline in water level, in some places as much as 90 feet, has occurred during the past 50 years in the industrialized centers of Norwood, Ivorydale, Lockland, Hamilton, and Middletown. However, measurements of water level in many wells during the past year have shown no serious drop from June 1938 to September 1939, and in the summer of 1939 in most wells the water level was slightly higher than a year ago, probably because of curtailed industrial activity and excessive rainfall.

DEVONIAN AND MISSISSIPPIAN RELATIONS IN SOUTHWESTERN PENNSYLVANIA

BY WILSON M. LAIRD

Detailed investigations of Upper Devonian and Lower Mississippian stratigraphy in southwestern Pennsylvania, made during the summers of 1938 and 1939, show that there is considerably more Devonian exposed in the anticlinal inliers of Chestnut Ridge and Laurel Hill than has hitherto been reported. The Devonian has been placed in the Conewango series on the basis of its unique paleontologic and facieologic aspect and its similarity to the Conewango beds of northwestern Pennsylvania. No greater hiatus appears to be present here between the Devonian and the Mississippian than in northwestern Pennsylvania. It becomes necessary to revise the paleogeographic picture of this part of the Appalachian trough during the late Devonian. In the Lower Mississippian, it was possible on the basis of faunal content, lithology, and stratigraphic position to segregate from the basal "Pocono" beds which are the equivalents of the Knapp formation of northwestern Pennsylvania. The age of the basal "Pocono" of western Pennsylvania is thus established.

BEGINNINGS OF MATHEMATICAL GEOPHYSICS IN GREAT BRITAIN

BY WALTER D. LAMBERT

Geophysics began in Great Britain toward the end of the seventeenth century with the *Principia* of Newton. It was necessarily "large-scale" geophysics, the

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theory of the figure of the earth and of the tide-producing forces. Newton was essentially correct as far as he went, and this pioneer work, which required not only the development of a new mathematical method but the application of it to physical problems, represents an astonishing intellectual achievement.

In the eighteenth century we have further developments along the lines laid down by Newton and the germ of one idea, interesting in the light of later developments, the idea of isostasy—the idea, not the word. In the scientific discussion of Mason and Dixon's boundary survey the idea almost emerged but did not; that was left for the next century.

In the nineteenth century men such as Stokes, Airy, Pratt, Kelvin, Tait, G. H. Darwin, and others prepared the way for the development of geophysics, especially of "small-scale" geophysics, in the twentieth century.

DEVELOPMENT OF STRUCTURES IN THE BASIN AREAS OF THE NORTHEASTERN UNITED STATES

BY J. R. LOCKETT

An area comprising southern Michigan, Ohio, northern Kentucky, Indiana, and Illinois is considered as a distinct structural province, which has not been greatly affected by lateral pressure, and within which the principal structural movement during Paleozoic time was subsidence. The Cincinnati and Kankakee arches are not the result of Paleozoic uplift but result from deposition over the cores of pre-Cambrian folded areas which remained positive while adjacent areas, into which their original overload and subsequent sediments were deposited, continued to sink. The Appalachian Revolution was the result of this continued subsidence during Paleozoic time. The types, trends, and relations of major and minor structures are discussed as results of the physical history of the area.

KARST VALLEYS

BY CLYDE A. MALOTT

The outer margins of the Mississippian limestone belt, notably in southern Indiana and in Kentucky, are characterized by a peculiar surface and underground drainage development. The gently dipping limestones were formerly covered by clastic Upper Mississippian strata. The minor valleys have been cut through into the underlying limestones, and karst features have developed in the valley floors. The tributary streams of the dendritic patterns reach into the karsted valleys and present dismembered distal ends of the former surface systems now without trunk-stream alimentation. The change from surface to underground drainage is marked by "dry-beds" and swallow-hole features, which receive and carry storm waters only. Sinkholes and sinkhole ponds with greater relief follow. Some dismembered side valleys terminate in deeply sunk individual courses, producing "blind valleys" which end bluntly against higher land. Occasional "karst windows" reveal short sections of subterranean streams which rise and sink in this striking karst feature. More commonly the underground drainage is directed out from under the karst valley, but occasionally the drainage is recovered in the lower section of the same valley, appearing as a "rise" or karst spring. Later stages of the karst valleys lead to the development of small karst plains hemmed in by clastic ridges or hills. Sloans Valley, Elk Spring Valley, Logsdon Valley, and Waterloo Valley, shown on the Burnside, Monticello, Mumfordville, and Horse Cave quadrangles, Kentucky, are excellent examples of karst valleys. More familiar ones are present in the Lost River region of southern Indiana.

CURRENT RESEARCH ON SUBSURFACE STRATIGRAPHY IN WEST VIRGINIA

BY JAMES H. C. MARTENS

Many thousands of samples of cable tool drill cuttings donated to the West Virginia Geological Survey have been examined and described. These samples give partial or complete information about the rocks penetrated by about 100 wells in the western two thirds of West Virginia, and a few wells in Pennsylvania, New York, Ohio, and Kentucky. Most of the wells start in Permian or Pennsylvanian rocks and end in Mississippian or Devonian. Several penetrate a considerable part of the Silurian, and one well in West Virginia and a few in eastern Kentucky have reached the upper part of the Ordovician.

Such correlations as have been made are based on general lithology, in some cases aided by detailed mineralogical studies, but without the benefit of any identification of fossils. A series of generalized columnar sections show the variations in thickness of the principal formations along lines running approximately north-south and east-west. More detailed sections show the thickness and character of the Mississippian rocks and their relation to the unconformities at the base of the Pottsville and at the base of the Greenbrier limestone.

BRIEF REVIEW OF GROUND-WATER CONDITIONS IN MICHIGAN*

BY C. L. MCGUINNESS

The paper gives a brief history of the ground-water investigations in Michigan that began in 1932 in co-operation between the State and Federal Geological Surveys. The initial purpose of the investigations was to determine areas suitable for the construction of shallow wells for immediate use in fighting forest fires. The paper describes briefly the methods of well construction developed by the Michigan Forest Fire Experiment Station in connection with these investigations. The paper also contains brief descriptions of the geology and ground-water supplies of both the Lower and Upper Peninsulas of Michigan and gives some data on the sources of supply of the 339 public water supplies in the State.

DIRECTED INDUCTIVE TEACHING OF ELEMENTARY GEOMORPHOLOGY TO THE PROFESSIONAL GEOLOGY STUDENT

BY F. A. MELTON

It is common knowledge among economic geologists who employ many men with bachelor's and master's degrees that engineering graduates, after a few years of field experience, have, in many cases, been able to do as well as geology graduates, where knowledge of surficial dynamic geology, sedimentary structures, and field relationships of rock masses is concerned. The geology graduates are usually unable to think in geologic terms at the professional level without additional field experience.

This does not mean that the engineers, because they are better trained in the fundamental principles of exact sciences are, therefore, better able to recognize and work with the natural science of geology. On the contrary, in the writer's opinion, it signifies that proper concepts at the geologic level are too often omitted from geologic curricula.

To remedy these difficulties geomorphic teaching should become more factual, and there should be a great increase in the time devoted to the recognition of

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physiographic, sedimentary, and structural features, as well as to the formation of visual concepts. In addition to increasing the time devoted to field trips, all other available means should be utilized to broaden the student's background of experience.

Broad generalizations do not ordinarily produce useful visual concepts. Neither are these concepts produced by simplified geomorphic classifications of plains and plateaus. Such simplified concepts could well be left to advanced courses, because of the inadequate "space perception" of all save exceptional students.

Emphasis upon visual concepts which the student need never supplant, and which can be used throughout all subsequent geologic work, seems to require a type of teaching which may be called directed induction.

MORE EFFECTIVE TEACHING IN THE GEOLOGY LABORATORY

BY ROBERT H. MITCHELL

Making certain basic assumptions concerning the duties of a teacher to improve his teaching techniques, we at Muskingum have made a study of our teaching procedures in the geology laboratory. A three-year study was made of the relative values of three different teaching methods in the laboratory, and the methods were compared statistically to discover which had been most effective. When it was discovered that the method which was most expensive in money and in teacher time and energy was the most effective, we set out to devise a new method which would be equally as effective and at the same time less expensive. The work-room method now being used is the outcome of this attempt. Since the plan is still in its developmental stages no effort has been made as yet to evaluate it.

This year we have been trying out a technique designed to make the laboratory work more flexible and thus better suited to meet the individual needs and differences of students.

BUILDING A FUNCTIONAL COURSE IN EARTH SCIENCE

BY C. F. MOSES

A teacher-student committee investigated the offerings of Geology and Geography as to their significance to the nonprofessional student. Later a course was built which does not recognize conventional boundaries, but which consists of a group of related points of interest each of which is the focus of all appropriate material regardless of its origin. These points of interest are selected on the basis of their pertinence to the life of the student now or later. Besides a common core of experience, each student carries on an individual option. Tentative evaluation indicates a degree of success for this functional course.

COMPREHENSIVE FLOOD CONTROL PLAN FOR THE OHIO RIVER BASIN

BY LEWIS A. PICK

The heavy losses in the Ohio River basin during the floods of 1936 and 1937 aroused interest to the need for comprehensive relief measures and resulted in enactment by Congress of legislation approving a comprehensive flood plan previously developed by the Corps of Engineers, U. S. Army.

This plan includes the forecasting of stages which might be attained by floods of the future and the nature of the works best suited to assure adequate protection against such floods. Whereas all methods of flood control are applicable, the principal reliance for main stream relief must be placed upon local structures such as walls and

levees, although reservoirs have their part in assuring the adequacy of the plan and provide a large part of the protection on the tributaries.

The procedure followed in the development of the plan consisted in determining (1) what measures of relief were essential on the tributaries, (2) the effect of these on the main stream, (3) what modifications thereof were necessary to provide the desired degree of main stream protection. The comprehensive plan, as finally evolved, comprises, in addition to flood-control works already constructed or previously authorized by Congress, a system of 49 reservoirs, which will cost $312,000,000; and about 235 levees, flood wall, and channel improvements costing about $300,000,000. Next June about $100,000,000 worth of these projects will be under construction, and it is anticipated that sufficient projects to absorb the entire expenditure of $200,000,000 now authorized by Congress will be completed by 1945.

SALT RESOURCES OF MICHIGAN

BY O. F. POINDEXTER AND R. A. SMITH

Salt has been known in Michigan since 1835. Commercial production began in 1860, and Michigan has generally led all States in annual production since 1886. There are several geologic formations—namely, Parma and Marshall sandstones and the Dundee-Monroe limestones—which yield commercial brines, and two basins in which rock salt was deposited—the Detroit River and Salina formations. The Salina salt basin underlies approximately 30,000 square miles in the Southern Peninsula of Michigan, and the aggregate thickness of the salt beds ranges from 500 to over 1200 feet. A conservative estimate of the total salt in the Salina of Michigan is 3000 cubic miles. Michigan could supply the world with salt for an indefinite period of time.

UTILIZATION OF LOW-GRADE MINERALS THROUGH MORE EFFECTIVE METHODS OF SEPARATION

BY OLIVER C. RALSTON

A new situation, which is not widely known or appreciated, must now be recognized in the nonmetallic mineral industry. Whereas the metalliferous minerals were mainly those suitable for concentration in the past, the nonmetalliferous industrial minerals are now being made suitable for use by adaptations of old methods and radically new methods. Froth flotation, filming and agglomeration, filming and entrapment on greased surfaces, scuffing off of undesired coatings, contact potential electrostatic methods, and numerous others are making unnecessary the production of naturally pure minerals from the ends of the earth and permitting production of purified from impure mineral deposits much closer to the markets. Profound changes in the commercial geography of many minerals may soon be expected as a result of these changes in technology.

IDENTIFICATION AND INTERPRETATION OF EROSION SURFACES IN THE ALLEGHENY PLATEAU

BY JOHN L. RICH

Aerial photographs of selected parts of the Allegheny plateau are used to illustrate the thesis that projected profiles or visual inspection of skyline elevations cannot be relied upon for the determination of the altitude of an erosion surface unless the region has not passed beyond the mature stage of the cycle. For all postmature stages an indeterminate amount of elevation must have been lost by the intervalley divides.

Erosion surfaces at several different elevations in the eastern part of the plateau

can be shown to be controlled either directly or indirectly *by* rock resistance. Physiographic evidence proves an enormous difference in the rate of erosion between certain shale horizons in the Pennsylvanian and the massive Pottsville conglomerate sandstone at its base. This difference is so great that two or more cycles can be brought to old age on the shales while the first cycle has scarcely passed infancy on the sandstone.

In view of the two types of complication outlined above, a plea is made for a re-examination of the physiography of the plateau; full weight should be given on the one hand to rock resistance and, on the other hand, to the stage in the cycle as affecting the reliability of the determination of the altitude of a dissected surface.

GRAVIMETRIC AND SEISMIC METHODS IN EXPLORATION GEOPHYSICS

BY MORRIS MILLER SLOTNICK

The two most important methods in use by petroleum geophysicists are the gravimetric and seismic. Although these methods as exploration tools are less than 20 years old, the success and development have been remarkable.

The underlying ideas of the torsion balance and gravimeter and of the refraction and reflection seismographs are described in this paper. Some of the related mathematical treatments leading to the geological interpretations are discussed.

HYDROLOGIC PROGRAM OF THE WEATHER BUREAU

BY THOMAS S. SOUTHWICK

The disastrous floods of recent years and the tardy public recognition of the destructive effects of soil erosion have focussed attention upon the prevention, control, and forecasting of floods, particularly in headwater areas. Intensive investigations are now under way in all phases of the hydrologic cycle.

The role of the Weather Bureau in the field of hydrology is to issue warnings of floods, conduct flood studies in the Hydrometeorological Research Section of the Bureau, and provide basic hydrologic and meteorologic data to other agencies.

Hydrologists make extensive use of mass rainfall curves and analyses of hydrographs of stream flow. A serious handicap has been the deficiency of precipitation data. Greater information is needed as to the areal extent of rainfall and to intensities, i.e., the rates of precipitation per various units of time.

In response to this demand for more data, the Weather Bureau is now engaged in a project, in co-operation with the Corps of Engineers and the Flood Control Coordinating Committee of the Department of Agriculture, for the establishment of a network of recording rain gages, to be supplemented by nonrecording gages. In addition to measurements of precipitation in the form of rain, snow gages in mountainous regions will record snowfall.

In hydrologic investigations, records of the past are equally important to those of the present, and these precipitation gages will thus become increasingly important as years of record accumulate.

OSTRACODES AS A POSSIBLE AID IN THE OLENTANGY SHALE PROBLEM

BY GRACE A. STEWART AND W. EDWIN HENDRIX

Fifty samples of shale collected by the junior author from 16 localities in central and northern Ohio have yielded an ostracode fauna of 53 species. Thirty-one of these are new forms, of which 28 are restricted to the central area.

A comparative study of the two faunas shows that there is little resemblance between them. They have in common only eight species, which in the central area are restricted to a 2-foot layer and in the northern area are distributed throughout the formation. The northern fauna appears to be a typical Hamilton assemblage and has many species in common with the Silica shale of northwestern Ohio, the Traverse of Michigan, and the Hamilton of southwestern Ontario. The fauna of the central region, on the other hand, is lacking in the typical Hamilton species. Two new species, *Nehdentomis dubius* and *Richterina symmetrica*, which are restricted to this area, represent genera previously recognized only in the upper Devonian of Europe. A new genus, *Franklinella*, is very close in its relationships to *Glyptopleura*, a genus not recognized below the Mississippian.

The fauna of the central area in general suggests a later Devonian age than the fauna of the northern area.

STYLOLITES

BY PARIS B. STOCKDALE

The solution theory for the origin of stylolites has recently been challenged. Such is accepted as wholesome in the interest of avoiding stagnation in geologic theory. The challenger, B. M. Shaub, has proposed a substitute "contraction-pressure" theory which claims that stylolites originate while sediments are in the unconsolidated state, from differential pressure and compaction which compelled "transfer of material by plastic flow." Since this is in strong contradiction to the solution theory, which argues for actual removal of the consolidated rock, and since the writer's works dating back to 1922 were a target of strong attack, the subject is being carefully re-examined.

The challenge has been made partly on theoretical grounds, attacking strongly suggestions made as to the manner of operation of solution in the development of stylolites and minimizing the primary contributions of the writer who assembled a mass of observations demanding the conclusion that removal of consolidated rock material has taken place in the making of stylolites. Unsatisfactorily explained or ignored in the challenge are such stylolite phenomena as (a) penetration of fossils, (b) interpenetration of adjoining stylolite-seams, (c) stylolite-seams along unconformities, (d) stylolite-seams along partings which cut across normal bedding planes, (e) stylolites along the contact of impressed pebbles in conglomerates, (f) stylolites in marble (rock metamorphosed long after the time of original lithification), (g) chemical relationships between the clay caps of stylolites and the limestone of the columns, and (h) other features.

The solution theory should not be discarded. Two questions should be raised, however: (a) Can stylolites originate in more than one way, and (b) are all features described as stylolites *true* stylolites?

DOLOMITES AND LIMESTONES OF WESTERN OHIO

BY WILBER STOUT

The bedrock throughout most of the western half of Ohio is either dolomite or limestone. The strata range in age from the Trenton formation in the Ordovician system to the Delaware formation in the Devonian system, and they vary in chemical composition through wide limits. From carefully made analyses the mineral components in the stone are determined by calculation. Such common rocks are of great economic importance and are an asset to the State of $25,000,000 or more annually. Either crude or prepared, they have wide application in many fields.

GEOLOGY AND ECONOMIC IMPORTANCE OF THE COAL-FORMATION CLAYS OF THE OHIO BASIN

BY WILBER STOUT

The coal-formation clays were derived from common shale silts and were purified by the organic agencies that deposited the coals. Clay and coal are always directly associated. Throughout parts of the Allegheny Plateau the coal-formation clays are well developed and have been employed for useful purposes since pioneer days. The quantities are generally large, and the qualities so adjusted that they are especially adapted for many classes of ware. Their chief economic importance is that they provide a wide range of products very essential for modern civilization.

CONSTRUCTIONAL "CAVE" IN CALCAREOUS TUFA

BY A. C. SWINNERTON

At the calcareous tufa mound formed by the Yellow Spring, at Yellow Springs, Ohio, the precipitating solids from the spring water are building forward an arch-shaped deposit creating a short tunnel approximately 15 feet deep, 6 feet wide at the base, and from 4 to 8 feet high. Preliminary studies indicate an annual addition of between 3 and 4 tons of tufa to the whole deposit from a spring flow of less than 100 gallons per minute. Restriction of flow to a channel in contrast to general surface flow-off is probably responsible for the arch form. The structure of the tufa indicates that the spring flow formerly built beds of travertine rather than arches. However, at least one "fossil cave" exists similar to the one described.

REQUIRED COURSE IN GEOLOGY

BY A. C. SWINNERTON

Extensive revision of the curriculum following the reorganization of Antioch College in 1921 resulted in the inclusion in the requirements for both the A. B. and B. S. degrees of a 20-week course entitled "An Introduction to the Earth Sciences". The content of the course, modified from time to time, is based on the supposition that awareness of the dynamic nature of environment and of the concepts of time and space is an important element of a liberal education. Conventional lecture methods are supplemented by a special laboratory program.

CORRELATION OF EROSION SURFACES IN WESTERN PENNSYLVANIA AND EASTERN OHIO

BY KARL VER STEEG

One of the major problems in Ohio and western Pennsylvania has been the correlation of the Worthington peneplain with its equivalent in the eastern Appalachians and western Ohio. The first to postulate the existence of the Worthington surface was Charles Butts. In the Kittanning Folio, he describes it as a definite peneplain, well developed in the vicinity of Worthington, Fenelton, Bradys Bend, and Red Bank Creek near East Brady, along the streams at an altitude about 100 feet below the Harrisburg surface. The Worthington surface is also described by Stone and by Stout and Lamborn in their report on Columbiana County in northeastern Ohio.

An examination in the field has convinced the writer that the Worthington surface is that portion of the Harrisburg peneplain which occurs on the uplands which border the streams. Everywhere in western Pennsylvania and eastern Ohio, the Harrisburg surface on the divides slopes gently toward the streams. This is to be expected,

as a peneplain is a rolling surface, higher on the divides and lower on the uplands bordering the stream valleys.

The elimination of the Worthington surface makes possible the correlation of the Harrisburg peneplain with the Lexington surface which bevels the lowlands of western Ohio.

GEOMORPHOLOGY OF THE CATOCTIN BELT

BY KARL VER STEEG

Arthur Keith in his *Geology of the Catoctin Belt* postulates the existence of a peneplain (Weverton) at altitudes from 1200 to 1300 feet, based on evidence in summits, gaps, and base-level remnants. The writer believes the Schooley and Weverton surfaces are one and the same. The ridge crests slope toward the Potomac as one surface without distinct break, a condition to be expected on a rolling, peneplaned surface. The residuals at 1200 to 1300 feet occur with many others at altitudes well above or below that level. Base-level remnants appear to be higher portions of the Tertiary peneplain, located at the headwaters of the streams in the Blue Ridge.

The wind gaps are so extremely irregular in altitude that they can have no value as indicators of former erosion levels. Certainly, they do not indicate a peneplain (Weverton) at 1200 to 1300 feet. To use Snickers Gap, Ashby Gap, and Manassas Gap, all within 100 to 200 feet of the same altitude, as proof of the existence of a former peneplain is a misinterpretation of evidence. One must consider the elevations of all the wind gaps in the Blue Ridge, and these are more irregular in altitude than those in eastern Pennsylvania. The absence of facets in the gaps, except where the structure is favorable or more resistant rock projects from the walls, corresponds with conditions in eastern Pennsylvania. There appears to be no definite evidence for the existence of intermediate peneplains between the Schooley and Harrisburg levels.

MEASURING THE REFRACTIVE INDEX OF A LIQUID WITH A MICROSCOPE

BY OTTO C. VON SCHLICHTEN

This paper demonstrates and describes a simple attachment to a standard microscope, to be placed between a low power objective and the tube, permitting the insertion of a glass disc with concave depression. The depression is filled with the liquid to be measured and covered with a plane glass plate. This acts as a liquid lens and when placed above objective alters the focus. The change in focus is a function of the refractive index of the liquid.

RATE OF METEORIC ACCRETION

BY FLETCHER G. WATSON, JR.

The rate of meteoric accretion is a datum of considerable interest to both geologists and astronomers. This discussion outlines the methods by which the incoming mass can be evaluated from an interpretation of the luminosity of meteors in terms of mass and a knowledge of the daily frequency of each magnitude. Despite the dispersion in the velocity and mass of meteors with the same luminosity, the total mass per magnitude interval can be estimated. From the fall of meteorites a minimum accretion of 10^8 grams per year is found, and the meteors may provide sufficient material to increase the rate to 10^{10} grams per year. Such a rate is equivalent to only 50 grams per square mile per year. Although the rate observed now cannot safely be extrapolated far into the past, at the present rate a layer only one centimeter thick would have been deposited since the origin of the earth.

SPATIAL TEMPERATURE OF METEORITES

BY FLETCHER G. WATSON, JR.

The possibilities that certain structures observed in meteorites result from extreme heating upon close approach to the sun or some other star are considered. It is pointed out that the temperature gradient about the sun is quite steep, the maximum temperature possible at 0.5 AU is but 555°K (282°C), at 0.3 AU is 715°K (442°C) and exceeds 1000°K (727°C) only within 0.15 AU. Both Meunier and G. P. Merrill have suggested that black chondrites may be produced by heating an ordinary chondrite to a low red heat (about 1000°K). Such heating, however, cannot account for the appearance of the normal structure in meteoritic irons, the Widmanstatten structure, because in stony-irons metal with this structure occurs adjacent to unaltered stony material.

The majority of meteorites, when they encounter the earth, are moving in orbits which cannot take them to the high temperature region near the sun. But it is impossible for close approaches to other stars to account for the observed frequency of black chondrites; namely, 3 percent. Hence, if the black chondrites result from preterrestrial heating, they must be permanent members of the solar system whose orbits have been appreciably altered by perturbations.

RETREAT OF THE LAST ICE SHEET FROM THE ALLEGHENY PLATEAU IN OHIO

BY GEORGE W. WHITE

The Scioto glacial lobe of the Wisconsin ice sheet advanced far southward into the till plain of Ohio, and its eastern border invaded the Allegheny plateau for a few miles. East of the Scioto lobe, in the Allegheny plateau, the Killbuck and Grand River lobes, impeded by the higher and rougher topography, did not advance nearly so far south. The ice retreated in the Scioto lobe by stages, end moraines marking halts of the ice border. The Killbuck lobe dissipated more slowly and much more irregularly and was without forward motion, as indicated by kame terraces and crevasse fillings in the valleys and by an absence of end moraines. The Wabash moraine is the earliest moraine which can be traced across both lobes. However, as late as in Wabash time, much dead ice remained in the plateau in the valleys to the south. Outwash from the Wabash moraine in the valleys of Black Fork, Jerome Fork, and Muddy Fork was deposited in contact with dead ice masses which persisted to within a few miles of the glacial boundary. The outwash is in the form of kame terraces and other ice-contact deposits rather than continuous valley trains. It therefore appears that all the drift of the Killbuck lobe south of the Wabash moraine is of the same age as that south of the Wabash moraine in the Scioto lobe.

DEVONIAN SYSTEM ALONG THE ALLEGHENY FRONT, PENNSYLVANIA

BY BRADFORD WILLARD

The Devonian system along the Allegheny Front in central Pennsylvania contrasts strongly with that farther east. It shows shifts of lithologic facies to the westward or northwestward. From these shifts, assumptions are made, and deductions drawn regarding the Devonian concealed beneath the Allegheny Plateau west of the Front. The Helderberg and Oriskany groups vary slightly. The Onondaga group, composed of a limestone overlying a shale in the lower Susquehanna Valley, changes largely to black shale northwestward. The Hamilton group in eastern Pennsylvania consists of the black Marcellus shale below the dark, sandy Mahan-

tango shale. On the Allegheny Front, especially northward, recurrent Marcellus type black shales are interbedded with the Mahantango. A shift to black shale in that direction is deduced. In the east the Portage group is dominated by sandstone which begins to overlap shale in the lower Susquehanna Valley. The group is practically all shale at the Front, except the basal Tully which changes from thin shale in the east to a few inches of limestone in the Susquehanna-Juniata valleys and to at least 200 feet of limestone along the northern part of the Front. The Chemung group shows no marked shift. The lowest Catskill continental red beds are middle Portage in the Delaware Valley, earliest Chemung in the lower Susquehanna Valley, and at least latest Chemung at the Front. Exposures of late marine Devonian on the Allegheny Plateau and in northwestern Pennsylvania show that the base of the continental facies continues to rise still higher beneath the plateau. Except for the Lower Devonian and the continental Catskill beds, there is a dominant tendency for the marine Devonian of Pennsylvania to change from coarse to fine clastic sediments northwestward with an accompanying loss of clearly defined lithologic boundaries.

BENLD (ILLINOIS) METEORITE OF SEPTEMBER 29TH, 1938

BY BEN HUR WILSON

Meteorites strike buildings and other man-made objects so rarely that an occurrence of this type always elicits unusual interest on the part of scientists and laymen.

The Benld (Illinois) Fall of September 29th, 1938, penetrating not only a garage building, but the top and cushion of the car contained therein, as well, is therefore unique in the annals of meteoric phenomena.

Concerning a number of phases of this Fall, the writer was enabled to make what is perhaps the most thorough and complete investigation on record, fully substantiated by photographic and other data, which he will present and discuss.

So far as is now known this is the only meteorite whose angular direction of striking the ground has been instrumentally obtained by accurate measurement of material or factual observations on the site of the fall.

HERMITAGE FORMATION (TRENTON GROUP) IN TENNESSEE*

BY CHARLES W. WILSON, JR.

The Hermitage formation is divided into seven members, each representing a different facies: (1) Curdsville limestone, (2) laminated argillaceous limestone, (3) blue clay-shale, (4) laminated argillaceous limestone containing abundant *Ctenodonta*, (5) massive coarse-grained, phosphatic limestone, (6) coquina composed of *Dalmanella fertilis*, and (7) irregularly bedded, silt-free limestone interbedded with silt.

In the Western Valley of Tennessee River 70 feet of (2) is exposed and 140 feet is reported from wells. Along the western part of the Central Basin the formation consists of 0-5 feet of (1), 50 feet of (2), and 20 feet of (6), which thins rapidly eastward. Near the center of the eastern part of the basin there is 20 feet of (7) underlain by 5 feet of (5), 10 feet of (4), 25 feet of (2), and locally up to 10 feet of (1). In the northern and southern parts of the eastern half of the Central Basin 25 feet of (3) is underlain by 30 feet of (2).

In Sequatchie Valley 5 feet of (1) and 65 feet of (7) constitute the formation.

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As (2) contains much silt and (7) contains only a moderate amount, and as (2) thins eastwardly, the source of clastic sediments of the formation in Central Tennessee is considered to have been from the west or southwest rather than from the east.

POST-HARRISBURG DEFORMATION IN THE SOUTHERN APPALACHIANS

BY FRANK J. WRIGHT

Northwest of the Fall Line which marks the boundary between the Atlantic Coastal Plain and the Piedmont Province it is difficult to determine the nature and extent of late deformative movements because of the absence of a sedimentary record. The correlation of marine transgressions and regressions along the seaboard with erosion cycles or partial cycles in the Appalachian Highlands has not been very successful.

The erosional history itself, including the deposition of alluvium in valleys, is the main line of attack open to the investigator.

Hayes, Campbell, and others have presented the idea that the Harrisburg and other late cycles in the Appalachians were terminated by uplift or uplifts concentrated along certain axes where maximum elevation was achieved. The lower parts of the erosion surface likewise owe their position to differential uplift. Campbell has stated that 90 per cent of the downward slope of the Harrisburg peneplane between the Appalachian Plateau and the Piedmont Province in the Potomac basin is due to deformation. The paper attempts to assemble the evidence that has been presented in support of warping of the later Appalachian erosion surfaces and to set opposite this evidence certain facts that apparently cannot be satisfactorily explained on the basis of warping.

JUNE MEETING AT MILWAUKEE

ELONGATE DRIFT HILLS OF SOUTHERN ILLINOIS

BY JOHN R. BALL

In widely separated areas throughout southern Illinois are low, elliptical hills of glacial origin. They are in the area of Illinoian glaciation and are somewhat densely segregated in the western part of the State. They probably fall into several categories as to mode of origin, including morainic, interlobate, and glacio-fluvial, but some hills which simulate the elongate drifthills are of eroded bedrock.

Salient features of common occurrence in these hills have instigated recent field studies in southwestern Illinois. The elongate drifthills surmount the uplands and are surrounded by wide expanse of flat driftplain or eroded moraines. In ground plan they are elliptical. Their long axes approximately parallel the existing drainage lines and in one or two cases the pre-glacial drainage lines.

Many of the hills show loess and till in the summit slopes and in road cuts. Others exhibit assorted and stratified drift in the deeper road cuts, and certain hills apparently possess a core of coarse gravels. In many hills till predominates, but well logs indicate appreciable amounts of gravel. The linear pattern of the hills, the presence of gravel or the gravel core, together with other associations in the drift, are considered as evidence supporting a hypothesis of glacio-fluvial origin for some of the hills.

ROLE OF SOIL CONSERVATION DISTRICTS IN LAND USE IN MICHIGAN

BY PAUL M. BARRETT

The Michigan Soil Conservation Districts Law differs from the Standard Act in that only "land owners" may vote in the referendum to establish a district, and a two-thirds majority of "land occupiers" voting on regulations is required before adoption.

The initiative for submission of the Act in the legislature and for the organization of the two Districts established has been strictly a matter of local responsibility. Participation by the Michigan State College Extension Service and the Soil Conservation Service in educational work or in formation and execution of a program has been only upon invitation and request of the people involved.

A serious problem confronts the people of the two Districts already organized. Light land, lack of cover, and strong winds from Lake Michigan create a "dust bowl" hazard. To prevent the spread of such conditions, the work approaches reclamation in some localities. The consequences of uncontrolled erosion are so evident and vivid that land owners are anxious to cooperate. In the first 6 months of participation in the program by the Soil Conservation Service, over 60 farmers have signed agreements and 150 are on the waiting list. On these farms under agreement, the Soil Conservation Service furnishes the map, plans, and one-fourth of the trees, if any are recommended. The farmer personally furnishes another one-fourth, and the District the remaining half.

Soil Conservation Districts in Michigan approximate the ideal in approach to the Land Use Problem in agricultural areas. It is the expressed desire of the people for a planned community enterprise to secure better land use and conservation of soil resources.

CAMBRIAN INLIER IN NORTHERN ILLINOIS*

BY ARTHUR BEVAN

During areal mapping in 1923-1924 of the Oregon quadrangle in northern Illinois, the writer considered an isolated small ridge of white sandstone along the east side of Rock River, opposite Oregon, to be St. Peter sandstone. Subsequent more detailed studies of this rock and meagerly exposed greenish glauconitic sandstones below it led him to conclude that the white sandstone is Dresbach, underlain by Franconia beds, both of Cambrian age. After recent re-examination of the section by members of the Illinois State Geological Survey the white sandstone has been re-assigned to the St. Peter.

Hence Rock River Valley, about 35 miles south of the Wisconsin boundary, contains a small inlier of the Cambrian Franconia formation, on which the St. Peter sandstone lies with marked erosional unconformity. Similar data are afforded by the log of a deep boring several miles to the north.

GEOLOGIC ANTIQUITY OF THE FOLSOM CULTURE AT THE LINDENMEIER SITE

BY KIRK BRYAN AND LOUIS L. RAY

The determination of the antiquity of an archeological site by geologic methods is difficult and is possible only if certain prerequisites are fulfilled. Single objects are always subject to challenge. A definite bed containing numerous artifacts constitutes a culture layer and furnishes the most satisfactory basis for geologic work. This culture layer must be related to some definite geologic event, which in turn can be related to other events or which is of sufficiently wide geographic extent to be related through a definite chain of reasoning to known geologic chronology of worldwide application.

The great fluctuations of climate in Pleistocene time afford the best chronology, and much effort has already been expended on the subdivision of the glacial episodes and on the dating of the later episodes by relatively precise means. The further refinement of this chronology and the interpretation of the changes in climate coincident with ice oscillations in regions remote from Pleistocene glaciers will require many workers.

The Lindenmeier Site in northeastern Colorado contains a culture layer, with Folsom artifacts; it lies above the floor of an ancient valley that can be traced into a local stream terrace which is part of a system characteristic of the great rivers of the Colorado Piedmont. By tracing this terrace on the larger rivers, a correlation can be made with the substages of the Wisconsin glaciation in the Colorado Front Range. The Lindenmeier Site is shown to be equivalent in age to the Corral Creek moraine (third Wisconsin substage). If correlation of this stage with the Mankato of the Middle West and the Pomeranian of Europe is correct, the culture layer of the Lindenmeier Site was developed at the end of the glacial advance dated by Antevs as 25,000 years ago.

SOIL KEY WITH LAND USE CONNOTATIONS

BY T. M. BUSHNELL

The soil is a natural body which is the product of material, modified by forces, acting through time. Profiles and three-dimensional forms are soil characteristics, and on them as bases different kinds of soils may be arranged in a tabular form or

* Presented by permission of the Chief, Illinois State Geological Survey.

"key" with those having similar parent materials on horizontal lines and those with certain similar profile features in vertical columns.

Parent materials are usually geological deposits with specific geographic distribution; the modifying forces, usually related to natural vegetation and climate, are conditioned by land forms; time is often a matter of geologic age. Thus the resultant soils depend upon all these factors. The soil key and soil maps which classify land on a pedological basis also indicate much in regard to all the genetic factors and correlate well with present land use patterns and land use capabilities.

SOME SIGNIFICANT UNCERTAINTIES IN PENNSYLVANIAN CORRELATION IN THE EASTERN INTERIOR BASIN*

BY GILBERT H. CADY

Recent classifications achieved by the field investigations of geologists adhering to the cyclical theory of Pennsylvanian deposition have greatly advanced our understanding of the stratigraphy of the Pennsylvanian system in the Eastern Interior Coal Basin of Illinois, Indiana, and Western Kentucky. Partly because of discontinuity of outcrop, preventing tracing of beds, and partly because of certain implications of the cyclical theory with respect to sedimentation, particularly the thickening of beds in the Basin, uncertainties exist with respect to correlations of certain important strata. Correlations of immediate interest concern the No. 5 coal bed, the Grape Creek coal bed, the Piasa, Lonsdale, Bankston Fork, Cutler, Carlinville, Shoal Creek, LaSalle, and New Haven limestones.

SPECIAL PHYSICAL FEATURES OF COALS IN THE ANTHRACITE-CRESTED BUTTE DISTRICT, COLORADO

BY E. C. DAPPLES

Coals in the Anthracite-Crested Butte quadrangles contain several rare features. Bird's-eye structure consists of rings concentric about a small central cone produced on cleat surfaces of no movement. Bird's-eyes are found in coals ranging from sub-bituminous to anthracite but are limited to microbanded clarain consisting of alternating thin bands of vitrain and attrital matter.

Pseudo cone-in-cone structure results from fracture but is limited to anthracite and is always found along surfaces of movement. Unlike true cone-in-cone, this structure is a striated surface produced along two or more intersecting fractures inclined to the bedding. Cones do not interpenetrate, and the effect is limited to the surface of the fracture. If fractures are gently inclined, the cones are likewise nearly parallel to the bedding.

Anthracites affected by intrusives, together with certain bituminous coals, commonly contain nodular or spheroidal masses. In the bituminous variety, the spheroids occur in clarain which is finely laminated with paper-thin bands of vitrain. The structure also appears in dense and megascopically structureless anthracite. Such coal, which is extremely resistant to shattering, tends to break along curved slickensided surfaces. Although spheroidal structure is commonly associated with thermally metamorphosed coal, it is not necessarily characteristic of such metamorphism; rather it appears characteristic of coal which consists chiefly of dense, finely laminated clarain.

A fourth special feature, designated as cuneiform structure, is observed only in prominent bands of brilliant vitrain in anthracite and consists of very closely spaced, minute fractures nearly normal to the coal banding. Cuneiform structure is be-

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lieved related in origin to the desiccation cracks common in the vitrain of bituminous coal.

MINERALOGY OF PENNSYLVANIAN UNDERCLAYS: SIGNIFICANCE IN RELATION TO INTERVALS OF WEATHERING PRECEDING DEPOSITION OF COALS*

BY RALPH E. GRIM

The Pennsylvanian coals of Illinois are usually immediately underlain by several feet of clay, known as underclay. Data are presented concerning the texture and the mineralogy of the underclays, and from these data it is concluded that the deposition of the underclays was followed by an interval preceding the accumulation of the coal during which the clay was exposed at the surface.

The underclays indicate that this interval was very short and/or that the weathering during the exposure was very feeble, because of topographic or climatic conditions. In the upper part of some underclays, iron was oxidized and calcium carbonate was leached, but there appears to have been no alteration of the clay mineral.

SEASONAL REGIME OF LAND USE, A FACTOR IN DETERMINING SOIL MOISTURE CONDITIONS

BY OTTO E. GUTHE

Research by the Soil Conservation Service on the Upper Licking Watershed in Ohio is leading to the development of a method for calculating soil moisture deficiency fluctuations over large areas. The procedure will provide a measure of the influence of the land use complex on soil moisture and on runoff retardation.

Only one phase of the study is considered here. Rain storms reduce or eliminate preexisting moisture deficiencies. Subsequently forces robbing the soil of capillary moisture are restored. The losses to the air must be considered, and adaptable field data must be secured. Transpiration from plants is one release of soil moisture to the air. The amount of transpiration is related to the type, density, and growth stage of vegetative cover. In 1938, a 10 per cent weekly sampling of observed cover types was secured for the six differentiated parts of the watershed by a survey of field conditions and cover on 1800 fields. With improved sampling and observational techniques, this survey has been continued.

The average weekly progress of field operations and of weekly growth for specific cover types in each area is tabulated and converted to total area acreages. No other source gives a quantitative, progressive picture of such phenomena as the extent of bare land, of crop harvesting, and of growth stages during the periods of survey. Because of the lack of adequate measurements of field transpiration, assumed transpiration potentials have been set up for different cover types at different stages of growth. Weekly isorithmic transpiration maps will be constructed on the basis of calculated indices and will furnish essential data for the larger study.

This type of survey also gives a measure of certain factors influencing soil infiltration. The condition of the soil surface during field preparation and the character of the vegetative cover have marked effects on maximum infiltration rates.

AMERICA IN AND OUT OF THE PHILIPPINES

BY WILLIAM H. HAAS

The Philippines have made more progress under American control in the last 30 years than they had in the three preceding centuries. Under the Spanish order

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lawlessness and even brigandage flourished. The present stable government is supported by an efficient constabulary of native soldiers. Where formerly individual rights were suppressed, today, under native judges, the supreme court carries out constitutional principles in a manner which should put many countries to shame. Roads and schools have been built, sanitation and individual health standards have been improved, and the standard of living has been raised to the highest for any oriental country. In one generation a medieval despotism has been transformed into a genuine approach to a democracy. Of course, no such progress would have been possible without a people competent and willing to cooperate.

All of this is to be suddenly changed by trading economic security for political ambitions. In March 1934 the Tydings-McDuffie bill gave the Philippines independence in name as well as in fact. They had long had the rights and privileges of American citizens both at home and abroad; they made their own laws, had their own currency, used their own postage stamps, and managed their own affairs. What emerged was a Malay State demanding officially from the American government its own sovereignty as a natural right.

On July 4, 1946, all political and economic relations between the two countries will cease. Politically the country is sufficiently strong to weather the storm, but, economically, collapse seems inevitable. Sugar, the major export, amounts to 63 per cent of the total in 1934, the last year before restrictions went into effect; all the sugar comes to the United States duty free. Cuba has been granted a tariff reduction from 1.5 cents to 0.9 cent per pound to avoid economic collapse. With production costs lower in Cuba than in the Philippines, the Philippine sugar industry will be wiped out. Other products will be similarly affected. Is it possible for a nation to rebuild its economic structure in so drastic a manner and keep its existing standard of living?

EVIDENCES OF SYSTEMATIC DEFORMATION IN THE CRUSTAL ROCKS OF NORTH AMERICA

BY ASHTON KEITH

Significant linear arrangements of numerous large structures and related surface forms have been traced through long distances and have been found to indicate giant zones of crustal mobility. In many places these areas are characterized by primary mineralization, seismic activity, or by various phases of vulcanism. Since mathematical determinations, as well as extensive field investigations, suggest that these zones of crustal deformation originated through large-scale tangential shearing stresses acting in conjunction with positive or negative vertical forces, the structures have been named megashears. Multiple parallel arrangements of these megazones of crustal mobility, constituting several systems of megashears, are believed to account for many puzzling facts of physiography. Intersections of two or more megashears of different systems create unusual crustal weakness, important mineralization, and foci of seismic disturbances or vulcanism. Mapping of the approximate locations of the principal megashears of the five systems is nearly completed and makes available information of economic importance to prospectors, engineers, and geophysicists. A simple and comprehensive system of nomenclature indicates the direction or trend of each structure, as well as its relative position, and provides for the inclusion of others which may yet be discovered and mapped.

DEVONIAN AND MISSISSIPPIAN STRATIGRAPHY OF JASPER PARK, ALBERTA

BY WILLIAM A. KELLY

Jasper Park is in the front ranges of the Rocky Mountains about 30 miles west of Jasper, Alberta. The Paleozoic formations exposed have an approximate thickness of about 4500 feet. The lower 1500 feet was not observed to be fossiliferous, but in lithology the section suggests correlation with the Sarceen series, which has been assigned to late Cambrian or Ozarkian by Kindle. A dark steel-gray granular dolomite, 150 feet thick, which overlies the Sarceen, possesses a coralline fauna of Devonian aspect and suggests correlation with the Lower Minnewanka of the Banff section and with the Jefferson of Montana. The dolomite is overlain by a group of calcareous shale and shaly limestone strata about 1000 feet thick, for which the name Blackface formation is proposed. The upper beds carry an Upper Devonian fauna dominated by varieties of *Spirifer whitneyi* and forms allied to *Leiorhynchus castaneum* var. *madisonense*. There is no lithologic equivalent of this formation in the Banff section, although the massive limestone about 800 feet thick, which overlies the Blackface formation, agrees closely both faunally and lithologically with the Upper Minnewanka of the southern area. The boundary between the Devonian and the Mississippian occurs within a shaly formation, the lower part of which probably agrees with the Exshaw (Warren) of Devonian age, and the upper part with the Banff shale of Mississippian age. Mississippian formations including the Banff and the overlying Rundle are less than 1000 feet thick. They include faunas of marked Madison and Brazer affinities. Characteristic of the later fauna are bryozoans, blastoids, and several species of colonial corals superficially resembling the genus *Lithostrotion*, but displaying in section marked differences from forms of that genus which occur in the standard Mississippian section. The corals are tentatively assigned to the genus *Lonsdaleia*.

METAMORPHIC CONTRASTS IN MINNESOTA AND MICHIGAN

BY CARL A. LAMEY

The Knife Lake slate-graywacke of Minnesota and the Michigamme slate-graywacke of Michigan, both of pre-Cambrian age, have been invaded by igneous intrusions, the former by the Duluth gabbro and the latter by the Republic granite. Hence both formations have been subjected to contact metamorphism as well as dynamic metamorphism. Since these formations had a somewhat similar geologic history and, as original sediments, were very similar in composition, they furnish an interesting comparison of the changes produced by metamorphism of argillaceous rocks.

Changes in mineral composition, texture, and structure were produced by metamorphism, but gabbroic intrusion caused changes which differ from those brought about by granitic intrusion. These differences in metamorphism apparently are characteristic of these two types of intrusives and may be of general application, as previously suggested by Grout.

LOBATE AND INTERLOBATE MORAINAL PHENOMENA IN NORTHEASTERN ILLINOIS

BY M. M. LEIGHTON

The writer discusses the striking differences in the constitution and topographic expression of the Wisconsin moraines from north to south in northeastern

Illinois, particularly those which belong to the Cary substage. These differences seem to be related genetically to the drainage conditions of the Lake Michigan lobe, of that part which was affected by interlobate relations with the Green Bay lobe and that affected by normal radial flow near the southern terminus of the lobe. The recession of these ice lobes and the migration of the zone of interlobate relations northward will also be discussed.

NEW TECTONIC MAP OF THE UNITED STATES: PROGRESS REPORT

BY C. R. LONGWELL AND C. H. BEHRE, JR.

The authors present in a series of lantern slides and maps a tectonic map of the United States which has been prepared in the course of the last 3 years by the several members of the Committee on Tectonics of the National Research Council. The structure contours of the more flat-lying regions in the United States have been drawn, and in regions of more intense structure conventional symbols are used to show the structure on a scale of such size as to make the map capable of superposition on the recently published geologic map of the United States.

MUTUAL PROBLEMS OF CONSERVATION: ENGINEERING AND GEOLOGY

BY M. L. NICHOLS AND BRUNO KLINGER

During the past decade soil conservation has been adopted as a national policy. Federal and State agencies, together with soil conservation districts and individual cooperators, are effecting programs of coordinated land use, are providing flood protection, and are applying soil and water conserving measures on farms and ranges. Many activities under the Soil Conservation Service program—protecting urban or highly developed areas against storm water or mud flows, retarding silting of reservoirs, developing water for securing better distribution of range cattle, to mention only a few—must be planned on the basis of geological information and of engineering procedures. These activities are discussed in this paper.

Soil conservation presents three principal problems: (1) Holding the soil in place, (2) keeping it tillable and productive, (3) preventing deposition of transported material where it is not wanted. While the engineer is concerned with devising methods for solving the problems, the geologist supplies fundamental information.

Water conservation, which is intimately bound to soil conservation, likewise calls for a united attack in determining sources of supply, improving distribution, achieving satisfactory storage of surplus supplies, and removing residues such as those resulting from irrigation.

In matters pertaining to flood control, geologists furnish indispensable information relative to drainage-basin characteristics, the water-conducting qualities of subsurface strata, and the availability of materials needed for the construction of works.

Although progress has been made toward achieving sustained productive use of our soil and water resources, the problems are so complex that they demand the concerted effort of many specialists.

CLASSES OF LAND ACCORDING TO USE CAPABILITY

BY E. A. NORTON

The development of action programs for making needed adjustments in land use has stimulated the demand for inventories of physical factors and pointed

out the necessity of their correlation with existing economic and social conditions. Intensive physical surveys, conducted by public and some private agencies for nearly 40 years, have largely taken the form of independent surveys in the various technical fields, with little coordination of information gathered in one field with that of another. Reorganization of farm and ranch units for permanency in agricultural production requires coordination of the physical, economic, and social conditions used as a basis for planning.

Classes of land according to use capability have been developed to meet the needs of planning unit reorganizations. The classes indicate the most intensive tillage or other use (range or forestry) that can be practiced safely, consistent with preservation of the soil and its plant cover. They are determined on the basis of the physical characteristics of the land and its climatic environment. They are defined in general terms, but the definitions must be modified in accordance with local conditions and practices. The classes may not be precisely comparable but conform in general with broad groupings over the entire country.

At least four groups of factors are considered in defining the classes: (1) Permanence of the soil, if cultivated; (2) productivity of the soil as conditioned by native fertility, capacity for retention and movement of water, salt content, or other factors; (3) presence of any factor that would interfere with cultivation, such as stoniness or lack of drainage; and (4) climatic environment.

The definitions are based on all available information with regard to practices and measures which are known to be adapted to specific conditions. As further information becomes known, particular areas may shift from class to class; areas are dynamic rather than static with respect to being classed for use capability.

SOIL CONSERVATION PROBLEMS IN THE GREAT LAKES BASIN OF OHIO, INDIANA, AND THE LOWER PENINSULA OF MICHIGAN

BY A. H. PASCHALL

"Soil conservation" means protection of the soil from loss or injury, and permanent maintenance of its productive capacity.

In the Lower Peninsula of Michigan and those parts of Ohio and Indiana which are drained by the Great Lakes, five major conservation problems exist: (1) Maintenance of the physical condition and productive capacity of the soil, especially in those areas requiring drainage; (2) control of water erosion; (3) control of wind erosion; (4) readjustment of the use of the land; and (5) recognition of such problems by land owners and occupiers.

The factors contributing to these problems may be grouped into geologic, geographic, and man-induced.

Topography and the nature and origin of the soil material determine the program of soil conservation. They in turn may create problems. For example, soils of the Lake Plain in Ohio are flat and heavy and can be properly drained only by maintaining a good soil structure.

Proximity to markets brings into use land of low quality which is subject to erosion. Specific examples are the fruit belt around Benton Harbor and the sandy lands in the vicinity of Grand Haven and Muskegon, Michigan.

Man-induced factors are: (1) Certain legislative acts; (2) exploitation of resources; and (3) lack of information.

Man's legislative act creating square sections and townships and property lines that follow this pattern is a major difficulty in development of water conservation plans. The acts opening timber lands, especially on sandy soils, to settlement

brought about exploitation of resources and caused many problems of maladjustment of land use. This is especially true of the Jack Pine area of central Michigan. Lack of information concerning the effects of exploitation has led man to attempt practices and measures that have resulted or will eventually result in destruction of the land.

SOIL CONSERVATION IN THE UPPER MISSISSIPPI REGION

BY DALLAS E. PERFECT

The Upper Mississippi region, which includes 63 per cent of the grade 1 (excellent) farm land in the United States, and 25 per cent of the grade 2 (good) land, is interested in control of water erosion. Erosion has destroyed 50 million acres of land in the United States and more than 600 million acres have lost from one-fourth to three-fourths of their topsoil.

Experiments at the Bethany, Missouri, soil conservation experiment station show that on plots with 8 per cent slope grown continuously to corn, topsoil is lost at the rate of 67 tons an acre each year. Soil loss from plots having thick stands of alfalfa was only one-fifth ton per acre annually. Loss on land under good crop rotations falls between these two extremes.

The erosion control program is demonstrated by the Soil Conservation Service, state colleges, and cooperating farmers in 19 projects and 75 CCC camp areas throughout the region and provides for surveys to determine (1) conditions such as soil type, slope, degree of erosion, and past land use on the farm; (2) the causes of the conditions; (3) proper land use for each acre; and (4) use of supporting conservation practices such as contour tillage, contour strip cropping, terraces, structures, and grassed waterways. Soil conservation may also assist in reducing the seriousness of floods by slowing up runoff and holding more water where it falls. In Illinois, Minnesota, and Wisconsin, 10 districts have been organized by farmers under enabling acts passed by State legislatures, and several others are in process.

The land utilization program of the Soil Conservation Service proposes

"to develop a program of land conservation and land utilization including the retirement of lands which are submarginal or not primarily suitable for cultivation."

It is attempting to correct economic and social maladjustments in rural areas.

EROSION SURFACES AND GLACIAL DEPOSITS WITHIN SOUTH PARK, COLORADO

BY WILLIAM E. POWERS

South Park, Colorado, is an elevated basin west of the Front and associated ranges, and east of the Mosquito or Park range. South Park has been etched by erosion in an area of tilted, folded, and thrust-faulted sedimentary rocks of Upper Paleozoic, Mesozoic, and Tertiary age, and of Tertiary volcanic rocks. At the east the crystalline Front Ranges are thrust westward over coarse Paleocene sediments derived from the west. Therefore Laramide orogeny here began in the Mosquito Range in late Cretaceous or early Paleocene time and was continued later by uplift of the Front Ranges and by thrusting toward the west. Still later deformation is proved by minor folding and normal faulting in lake beds and lavas of late Oligocene or Miocene age.

The dominant landforms within South Park are flat gravel-capped erosion surfaces now forming discontinuous remnants at several levels. All but the highest

lie within the South Park drainage basin and decline eastward in conformity with present drainage but are lost in the narrow crystalline canyons of the Front Ranges. The two lowest correlate with glacial moraines of two ages. The highest or Badger Creek erosion surface marks a stage before the present Park area was delimited from its surroundings by erosion. In Badger Creek time (probably late Pliocene) a vast erosion surface stretched southeast and east from the Mosquito Range across areas now eroded › form South Park and the low ranges farther east. Uplift, perhaps warping, and erosion in several stages have led to the present topography.

Glacial moraines and outwash of two stages are present at the north and northwest.

RECENT ADVANCES IN THE STUDY OF PHYSIOGRAPHIC DIVISIONS OF CANADA

BY WILLIAM E. POWERS

Chief advances in the description of Canadian physiographic regions include the subdivision of the Cordillera, increased knowledge of Arctic regions, better understanding of submerged topographies and other evidences of depression and uplift, and detailed knowledge of local geology.

Interior ranges and plateaus of the Cordillera, including the Coast Range, are older than the Insular Ranges on the west and the Rocky Mountains on the east. The plateau erosion surface may have once included the adjacent mountains, the latter having been raised later by warping or faulting. The Rocky Mountain Trench has greater historical than structural significance, marking the zone of demarcation between Laramide and Jura-Cretaceous deformation. Approximately 20 subprovinces are differentiated in the Cordillera.

Eastern Canada bears evidence of an immature erosion cycle following "Laurentian peneplanation". Hudson Bay is a submerged coastal plain bearing a youthful dendritic valley system. Fiords such as Lake Melville and the lower Saguenay, a submerged 100-fathom shelf along the Labrador coast, and the deeply drowned inner "Laurentian river valley" in the St. Lawrence trough indicate an erosion cycle subsequent to peneplanation.

Postglacial uplift can hardly correlate with thickness of the ice caps. Although the center of uplift (700 feet) lies east and southeast of Hudson Bay, greatest uplift (800 feet) occurred at Cape Wolstenholme, far to the north.

The age of the "Laurentian peneplain" and whether it consists of one or many facets are still in doubt. Uplift probably occurred in late Pliocene. The abrupt termination of the elevated peneplain at the precipitous Labrador Coast remains unexplained but suggests either faulting or separation from Greenland.

KILLARNEAN INTRUSIVE ROCKS NORTH OF LAKE HURON

BY T. T. QUIRKE

A study of all Killarnean intrusive rocks known between Sault Ste. Marie and Sudbury, and between Sudbury and Parry Sound, Ontario, reveals great differences in the nature of the rocks. The variations when studied in detail indicate a distinct relationship between method of emplacement, chemical and mineral compositions, and geographical distribution. In general the depth of emplacement increases from west to east, as indicated by textural and mineralogical features. An increase in degree of basicity, a shift towards the lime plagioclases and decrease in silica and the alkalies also accompany the general increase in deep zone conditions

toward the east. All the intrusions of this group known to the writer are classified and tabulated according to (1) Texture and structure, (2) chemical composition, and (3) mineralogical relationships.

MEASUREMENTS OF THE POLARIZING ANGLE, USING A SINGLE-CIRCLE GONIOMETER

BY T. T. QUIRKE AND R. C. GUTSCHICK

An apparatus was devised and assembled for measuring the polarization angle of various isotropic and anisotropic substances, using only reflected light. This paper describes in detail the apparatus and procedures used and presents the observational data and net results. The method provided a curve of data, balancing equal intensity of polarized light on opposite sides of the Brewster, or polarizing angle, using cross polarized light from the collimator. The curve made a great increase in the accuracy of the observations. In many cases a perfect curve, reading to an absolute minimum, was prevented by slight elliptical polarization effects. In any case, a minimum point in the curve denotes accurately the position of the polarization angle. An insuperable objection to the light intensity method is due to the dimness of illumination of the matching prism or other visual check at the most critical part of the curve. This study indicates the advantages of devices which detect the phase change of reflected light at the Brewster angle rather than changes in degree of polarization. (Geological Society Project.)

OVALS OF REVOLUTION FOR ANISOTROPIC MEDIA

BY T. T. QUIRKE AND T. L. HURST

Studies of the relationship between the ellipsoid of revolution and the velocity ovals of anisotropic media indicate that the recognized conditions lead to appreciable, observable differences. In minerals of low birefringence the distinction is not material, but with calcite the differences were observable with a Smith refractometer. The relationships established are so definite that, with the value of the ordinary ray index known and a single point known on either the ray velocity ellipse or the wave front velocity oval, it is possible readily to compute the otherwise unknown extraordinary ray index of refraction.

Measurements were made for a series of different angles in a calcite crystal using plain light, sodium light, and polarized sodium light. The use of polarized light promoted accuracy of observation within the limits of adequate illumination. (Geological Society Project.)

MEASUREMENTS OF INDEX OF REFRACTION IN ANISOTROPIC MEDIA

BY T. T. QUIRKE AND W. C. LACY

Test pieces of calcite were prepared in order to measure directly the refraction of the ordinary and extraordinary rays in all crystallographic directions. Two half cylinders were made from transparent calcite crystals; one was a semicircle in cross section, and the other a half ellipse. The dimensions of the ellipse were directly proportional to the values of the velocities of the extraordinary ray—parallel and normal to crystallographic *c*. The minor axis of the ellipse was made parallel to and the major axis normal to crystallographic *c*. The semicircular specimen was cut with the crystallographic *c* parallel to the diameter. For both specimens, observations were made on a goniometer with transmitted light. The ordinary ray emerged, refracted only at the surface of incidence of the semicircular cylinder, but

the extraordinary wave normal was also refracted when leaving the calcite-air surface. The extraordinary ray was observed to follow a course in air after deflection at the surface of the calcite half cylinder which agrees with the course to be expected according to computations. With the elliptical half cylinder the extraordinary ray appeared to emerge from the calcite with almost no deflection from the computed course of the wave normal, and the ordinary ray of course was deflected.

To check the accuracy of the values obtained, observations were made on an optically true semicircular cylinder of identical size made by Bausch and Lomb Optical Company. This half cylinder produced results essentially identical with those of the home-made specimen. (Geological Society Project.)

CHEBOYGAN COUNTY LAND UTILIZATION RESEARCH PROJECT—AN ATTEMPT AT INTEGRATED STUDY

BY W. F. RAMSDELL

Land use planning efforts have been tremendously stimulated through economic, social, and political stresses incident to the depression years following 1929. Coincident with these external pressures, we have had cumulative physical manifestations of the need for planning and adjustments in land use. Dust storms, floods, and mounting erosion losses are related in cause and effect to the increased efforts in the field of land use planning.

In previous periods, land use studies and action programs have been carried out primarily by single individuals or organizations, with scant participation by the major social sciences. Attempts at comprehensive land use studies, involving participation of representatives of all interested disciplines, present certain restrictions and problems along with obvious advantages. The Cheboygan County land use research project, under the leadership of the University of Michigan's Institute of Public and Social Administration, has now completed 2 years of a planned 3-year study of this character. The primary objective of the project has been

"the exploration of different forms and types of cooperation, integration, and coordination of field work and office work, between individuals, groups, and disciplines, and the establishment of general principles and development of techniques and methodology."

A progress report on the project enumerates the plan of study and degree of accomplishment to date and shows that representatives of the fields of interest concerned believe that all have profited greatly through working from a common field headquarters, conducting group discussions, and direct co-operation among disciplines on related or the same problems. Rate of progress apparently is retarded, and the preparation of a comprehensive integrated final report, scheduled for the third year of the project, presents some serious difficulties.

SUBDIVISION OF THE LAST GLACIAL STAGE IN THE SOUTHERN ROCKY MOUNTAINS

BY LOUIS L. RAY

The glacial history of the Cache la Poudre drainage basin in the northern Colorado Front Range has been used in dating the culture layer at the Lindenmeier (Folsom) archeological site. Five substages of Wisconsin glaciation are recognized.

To extend this chronology and validate the substages, a reconnaissance was made of the Southern Rocky Mountains, from southern Wyoming to Santa Fe, New

Mexico. The earliest, or Twin Lakes substage, is named for the "early moraine" at Twin Lakes in the Upper Arkansas Valley, mapped by Capps. The ice advance was about the same magnitude as that of the second substage. Terminal moraines of Twin Lakes lobe are rare, and evidence of ice advance is based on patches of weathered till on the valley walls above the till of the second substage, or on lateral moraines. The great lateral moraines in the Rocky Mountain National Park region are believed to be products of the Twin Lakes substage, which carries younger debris of the second substage. In the Huerfano Valley of southern Colorado, remnants of the Twin Lakes substage lie on rock benches above the inner canyon, in which three later substages are represented by moraines. This is analogous to the Durango stage of Atwood and Mather in the San Juan Mountains, and these glacial advances may have been contemporaneous.

Throughout the Southern Rocky Mountains the second, third, and fourth, or Home, Corral Creek, and Long Draw, substages can be readily correlated from valley to valley. These substages are named for moraines in the Cache la Poudre area.

The fifth, or youngest, substage, represented in some cirques by protalus ramparts, is named the Sprague substage, because it is a definite moraine below Sprague Glacier in Rocky Mountain National Park.

The validity of five distinct substages of Wisconsin ice advance, separated from one another by interstadial ice retreat or complete disappearance, is based on: (1) The character and topographic position of the moraines; (2) the relationship between successive terraces (valley trains) and the terminal moraines, as determined in the Cache la Poudre Valley; (3) the differences in weathering of the tills composing the moraines; and (4) the reported finding of an old soil zone between tills assigned to the Twin Lakes and Home substages.

RELATION OF FOREST COVER TO SOILS IN THE LAKE STATES

BY EUGENE I. ROE

The disappearance of the original forest cover over large areas of the Lake States and the subsequent invasion of this land by aspen, scrub oak, paper birch, various brush species, and grass, have greatly obscured the relationship that existed between soil conditions and the forest types that were characteristic of the stands of prelogging days. A comprehensive study on sample areas distributed throughout the forested region has revealed a closer correlation between the forest cover types and the moisture relationships of the soil than with soil types as recognized in the soil surveys of the United States Bureau of Chemistry and Soils. Disregarding aspen, which occurs on a wide range of soils throughout the Lake States, the most prevalent type on all upland soils of the region characterized by the northern hardwood climax forest is northern hardwoods (sugar maple, yellow birch, beech, basswood), irrespective of the character of the subsoil. Pines are found on sands, and oaks on loamy sands and light loams with clayey subsoils and to a lesser extent on the sandy subsoils. The mucky soils support bottomland hardwoods and the true peat coniferous swamp. In the more northern region formerly dominated by the white spruce-balsam fir climax, pine occurs wherever the subsoil is sandy; spruce and balsam occur on loams and heavier soils having rocky, sandy, or clayey subsoils. Northern hardwoods are also found on heavy soils, and coniferous swamp on the mucks and peats.

PARAGENESIS OF AMYGDULAR MINERALS AROUND DULUTH, MINNESOTA

BY A. E. SANDBERG

Preliminary study of amygdular minerals in Keweenawan basalts around Duluth indicates the following paragenesis: (1) Quartz (some agate); (2) chlorite, practically contemporaneous with but generally earlier than (3) epidote; (4) calcite and laumontite; (5) quartz. Prehnite begins and ends before copper, and both occur with calcite and laumontite. Magnetite and hematite occur sparingly and are early. Pyrite in small amount is late. In one locality garnet occurs with calcite.

A hydrothermal origin of these minerals is deduced. That deposition is not a recent event but was essentially completed before the close of the Keweenawan is indicated by the fact that wherever amygdules occur in basalt near larger, younger Keweenawan intrusives, both amygdules and host are recrystallized to hornfels.

Deuteric action may have contributed to amygdule development, though many lavas elsewhere lack amygdules. Purple fluorite occurring exclusively in felsites is doubtless deuterically related to them; barite, calcite, and quartz are also common in felsite. The characteristic minerals of basalt amygdules occur along joints, in interflow clastics, and in some intrusives cutting flows—facts which indicate a post-deuteric origin.

Few points, if any, in Northeastern Minnesota are more than 2000 feet in a straight line from some younger intrusive. Probably proximity of intrusive and kind of flows were factors determining the kind of amygdular minerals. Epidote is abundant near the top of the Duluth gabbro; laumontite is prominent farther away; prehnite and copper are localized; fluorite is not known in basalts; and epidote, chlorite, and laumontite are scarce in felsite. (Geological Society Project.)

STRATIGRAPHIC DISTRIBUTION OF AMERICAN COAL BALLS*

BY JAMES M. SCHOPF

During the past few years coal balls (mineral concretions in coal which contain petrified plant tissues) have been discovered at no fewer than seven different horizons. These occurrences are discussed with particular reference to their stratigraphic position. They are intermediate in age between those best known in Europe. It thus appears that our coal ball material is particularly suited to precise comparative studies which will elucidate the evolutionary trends within the common genera of coal ball plants. Most of the studies of the past have been concerned with questions of "systematic position," *i.e.*, studies relating to major botanical problems.

The material collected from numerous, instead of few, horizons requires study in which emphasis is placed on "taxonomic precision." Studies of this sort are more likely to be of aid to the stratigraphic geologist than the classical coal ball studies of the past.

METHODS OF CORRELATION OF STRAND DUNES OF THE LAKE MICHIGAN BASIN

BY I. D. SCOTT

The basis for deciphering the history of the dunes about Lake Michigan is the concept that they were formed as shore features and, therefore, are representative of definite lake stages. Six glacial and post-glacial stages which were productive of dunes are recognized as Glenwood, Calumet, Algonquin, Nipissing, Algoma, and Michigan. With the exception of Algoma and Michigan, they occurred as flood conditions following low-water periods. The shores and therefore the dunes of the early stages

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(Glenwood and Calumet) are preserved because the beaches of the later stages did not encroach on them. Likewise north of the hinge line the shores of the later stages are well preserved, but within the area of horizontality no beaches of these stages are preserved except in embayments. The dunes were formed from the sands of bay-mouth bars and, although encroached upon by waves during the various stages, were never completely obliterated. In such locations from Berrien to Benzie counties, Michigan, the dunes occur as closely crowded ridges which locally cover or overrun those of earlier age.

The method used in correlating the dunes of this region makes use of four criteria: elevation, position, stage of development, and soil profiles. The purpose of this paper is to discuss the theory and practice of using these criteria in correlating the dune ridges with the various stages of glacial and post-glacial lakes of the Michigan basin.

LANDSLIDES IN RELATION TO AGRICULTURAL AND ENGINEERING PROBLEMS

BY C. F. STEWART SHARPE

The significance of landslides and other mass-movement processes in soil formation and removal, land sculpture, and human welfare is only now becoming fully recognized. Knowledge of these processes is as vital to the Soil Conservation Service for proper planning of conservation measures on unstable lands as it is to engineers engaged in construction and maintenance of highways, railroads, dams, and communication lines.

The climatic and geographic distribution, causes, and behavior of the various processes are being studied. Of the types most significant to agriculture, soil-creep is almost universal; slumping, earthflow, and debris-avalanche are characteristic of humid lands, mudflow of semiarid conditions. These types, as well as falls and slides of rock and debris, and subsidence, are common engineering problems.

Field work now in progress in rugged areas of eastern Ohio and extending into Pennsylvania and West Virginia reveals the abundance of slumps and earthflows in that region. Movements are directly related to the numerous coals, clays, and shales of the Pennsylvanian and Permian sections. The role of mass-movement in sculpturing the landscape of this region and in determining proper land use and safe highway and railroad location is even more significant than had been anticipated. On the basis of the stratigraphic, climatic, edaphic, and land-use factors, a program of future land use in areas subject to slips is being formulated.

Coordinated effort and the assembling of unpublished information now in the hands of soils specialists, foresters, agronomists, geologists, and engineers will speed solution of these problems.

GEOLOGICAL ASPECTS OF WASHINGTON ISLAND, WISCONSIN

BY ROBERT R. SHROCK

Washington Island is the largest of the islands strung across the entrance to Green Bay and is important geologically because it is a connecting link between Door Peninsula of the Wisconsin mainland and Garden Peninsula in Michigan. The island is a southeasterly sloping tabular mass of Silurian dolomites rising some 300 feet above a foundation of Ordovician (Richmond) shale and having an area of about 23 square miles. The strata, constituting a succession over 300 feet thick, belong to the Mayville, Burnt Bluff (Byron and Hendricks dolomites), Manistique (Schoolcraft and Cordell dolomites), and Racine formations (in ascending order), and dip southeasterly 25 to 35 feet per mile. The Niagara Escarpment is conspicuous along the

western edge of the island where it has a height of about 300 feet. The upper half of the precipitous cliff rises above the waters of Green Bay; the lower half extends below water and is well shown on bathymetric maps of the bay.

The island was sculptured into a sloping tableland before being overridden by the Pleistocene glaciers. It was almost completely covered by the waters of the glacial Lake Algonquin and today is still about half submerged beneath Green Bay and Lake Michigan. Prominent wave-cut benches and caves and wave-built beach ridges of cobbles and roundstones are well developed at numerous places. These mark four prominent water planes: Lake Algonquin levels at 680 to 670, 650, and 630 feet above sea level; Lake Nipissing at 600 feet. The mean elevation of Lake Michigan is 580± feet, and benches and cobble ridges are now developing at that general level.

NIAGARAN BIOHERMS OF THE MILWAUKEE REGION

BY ROBERT R. SHROCK

Among interesting geological features of the Milwaukee region are fossiliferous bioherms of Niagaran (Racine) age. Many choice specimens in the collections of Day, Teller, Greene, Hoy, and others came from these ancient reefs. Hall first described and correctly interpreted the reefs in 1862, and Chamberlin reported on them in detail in 1877.

Typical bioherms consist of two parts—a central massive fossiliferous core of dolomite and a peripheral zone in which crudely stratified relatively unfossiliferous dolomites dip gently away from the core. These flanking beds merge inward with the core; they flatten outward and grade into thin-bedded sparingly fossiliferous interbiohermal strata which constitute the regional stratigraphic sequence. Bioherms are present at four places in and near Milwaukee and also occur farther afield at numerous localities. The best known of the four is exposed in the old Schoonmaker quarry in Wauwatosa; a second lies along the southwest side of the Menominee valley in the grounds of the National Military Asylum; a third is exposed in southern Milwaukee where 25th Avenue crosses the Rapid Transit tracks; a fourth is poorly exposed in a small water-filled quarry along the C.M. and St. P. tracks about a mile northwest of North Milwaukee. The flat-lying interbiohermal beds are exposed along the Menominee valley in the Manegold and Story quarries in Milwaukee and in quarries 2 to 3 miles northwest of Wauwatosa.

The bioherms represent ancient calcareous mounds built above Silurian sea bottoms by algae, stromatoporoids, corals, mollusks, and other organisms. The flat bottoms between the densely populated mounds were sparsely inhabited and upon them were deposited the calcareous muds constituting the interbiohermal strata.

SUMMARY OF THE MASTODON AND OTHER FINDS IN THE AREA OF AURORA, ILLINOIS

BY CLARENCE R. SMITH

The mastodon remains found at Aurora, Illinois, during the year 1934 have been of much interest with respect to the early postglacial history of that locality, and several reports have appeared in the scientific literature. Local interest has also revived the recollection of other finds which have been made in the vicinity since settlement by the white man. In view of the scattering of the accounts and the fact that several of the finds have not previously been mentioned in the literature, it seems desirable to assemble the available data into a summary, listing the various specimens, giving references to publications already made, and presenting certain data not previously recorded.

Along with the mastodon bones of 1934 were also found, in the same marl deposit, remains of the trumpeter swan and of the giant beaver. In the peat layer above the marl were found several horns and numerous bones of Virginia deer; also a skull and other parts of elk.

Concerning the finds made prior to 1934, much of the information has been obtained from long-time residents. Confirmation of dates and circumstances has in most cases been obtained from newspaper reports of the times.

WEATHER PITS IN GRANITE OF THE SOUTH CAROLINA PIEDMONT

BY LAURENCE L. SMITH

At two localities in the Piedmont of South Carolina unusual basins occur on the surface of bare domelike granite masses. These basins have nearly flat floors and are almost symmetrical. The majority range from 10 to 40 feet in diameter, and from 1 to 3 feet in depth. They have been formed by localized weathering. After a miniature pit is started, weathering at that point is accelerated by the action of moisture and vegetation. Microscopic and chemical studies indicate that the granite in the pits weathers largely by alteration along mineral boundaries which results in crumbling of the rock. The fragmental residue is removed largely by the flushing action of rain water. A portion is carried out in solution, and some may be blown out by wind.

AMAZING HIATUS (ALGONQUIN-NIPISSING) IN LATER HISTORY OF THE GREAT LAKES

BY GEORGE M. STANLEY

Over the northern Great Lakes the Algonquin beach is greatly uplifted and has a steep slope, whereas the Nipissing beach exhibits very moderate uplift and tilt. The light fragmentary intermediate beaches (lower Algonquin) are deformed essentially as the Algonquin beach, and all have steep slopes (2.6 to 3.0 feet per mile) in contrast to the Nipissing beach (0.5 foot per mile). They pass southward beneath the Nipissing beach, as impounded beaches in several localities indicate. The lowest of these yet studied (Isle Royale) is several hundred feet below the Algonquin beach and, if extended southward, almost as much below southern Lake Huron.

From the Algonquin beach the lake must have been lowered by successive stages several hundred feet (in Lake Michigan basin, only to floor of submerged valley through Mackinac Straits), and much time may well have transpired during the period of lowering, which was due presumably to glacial release of new passages. Judging from the rate of present tilting in the region, a much longer time must have been required for uplift to have elevated the lake many hundred feet again to culmination at the Nipissing beach. Thus, between the Algonquin and Nipissing beaches, only 10 vertical feet apart below the hinge-line, a great hiatus must be visualized—undoubtedly a long lapse of time—and a magnificent fluctuation in level which probably rivals the sum total of all other late glacial fluctuations of the lakes combined. (Geological Society Project.)

CHARACTERISTICS OF PUBLIC LANDS IN MICHIGAN

BY F. P. STRUHSAKER

Michigan has 20,000,000 acres of nonagricultural land out of a total land area of 36,000,000 acres. Most of the nonagricultural land is located in the so-called cut-over counties of the north, while the agricultural land is mainly in the southern part of the State.

The historian might record the several phases of land utilization in Michigan under the headings (1) Pioneering, (2) settlement, (3) conservation, or forestry and conservation. These phases have witnessed many types of land use and misuse.

At a relatively early date Michigan had an effective law for the reversion of tax delinquent property to State ownership, and so public land administration has been rather continuously a job for State officials. The State is working closely with federal departments and bureaus in the administration and development of its wild public lands; and, with ever-increasing acreages coming into public ownership—probably permanently or at least for several decades—Michigan is now entering upon a fourth phase in its wildland affairs.

SOIL CONSERVATION IN WESTERN CANADA

BY L. B. THOMSON

The soil conservation program in western Canada began with the establishment of the Prairie Farm Rehabilitation Act by the Dominion Government in 1935. Prior to this time, however, years of research and experimental work had been conducted by the Dominion Experimental Farm system in the Plains area of over 50 million acres. This organization initiated and administered the new Act, for there was a nucleus of trained and experienced men to guide and build an effective program to cope with soil erosion and related problems.

The paper will present the results of research and their application to soil conservation. The major factors limiting crop production are moisture conservation, soil drifting, and weed and insect control. Fifteen years of soil moisture investigations have resulted in important changes in cultural methods of crop production. Old practices have been discarded as a result, and agriculture is gradually being reformed to suit the climate rather than trying to make climate fit the agriculture. Newer methods of soil-drifting control have modified farm practice. Research and organized methods of soil-drifting control will be discussed.

The steady co-ordination of the research worker and the farmer has produced effective results in a soil-conservation program. An attempt has been made to develop a program on the self-help plan. Such programs are not spectacular but have a lasting benefit in building a permanent agriculture. This paper purports to present the point of view of western Canada as a result of several years' work in the Prairie region.

ECONOMIC GEOGRAPHY OF THE ILLINOIS OIL MARKET AREA

BY WALTER H. VOSKUIL

The rapid rise in the output of petroleum in Illinois since the discovery of oil in the deep basin has brought about critical problems in the disposal of both crude oil and refined products. Practically all oil produced in Illinois is marketed in the Central Refining District in competition with oil from the mid-Continent field. The competing States in order of importance are Oklahoma, Kansas, New Mexico, and Texas. From January 1937 to March 1939, the contribution of Illinois' output to the Central Refining District rose from 2.8 per cent to 35 per cent of the total crude run to stills. This rapid increase in production not only disturbed the crude oil market of the mid-Continent producers, but, partly because of inadequate pipe line facilities and partly because of the reluctance of refiners to break connections entirely with producers in the mid-Continent field, it also supplied a quantity of oil that could not find an immediate outlet to existing refineries.

CHANGES IN THE MANUFACTURING COMPLEX OF HAMISTON, ONTARIO

BY HAROLD B. WARD

No Canadian city, in proportion to its total population, is as dependent on manufacturing as is Hamilton.

Hamilton owes its importance as a manufacturing city to its location at the base of the Niagara Escarpment at the western end of Lake Ontario. From the time of settlement until 1858, when the first railway in Upper Canada was built to Hamilton, the city was an important shipping point only by virtue of its position on the lake. It became a manufacturing city because of a lucky wording in the charter of the first railway, whereby the Great Western Railway established iron mills for the maintenance and repair of its rails and rolling stock.

The railway mills attracted other industries, and by 1887 Hamilton was known as a "prominent manufacturing city." Three environmental changes that culminated in 1896 started the city on the modern phase of its development. These were (1) Completion of a blast furnace, (2) building of a railway that led to new outlets, and (3) inception of the cheapest and most efficient electric power in Canada.

The city pattern and environmental complex grew increasingly attractive for manufacturing plants. Centrifugal forces had become effective after the blast furnace had been located east of the original manufacturing area and were strengthened by the building of the International Harvester plant on a site adjacent to the blast furnace. Hamilton could advertise large areas available near the waterfront and near a primary iron plant with rail connections and cheap power.

Later changes have tended to segregate manufacturing into three general areas—the heavy iron and steel mills at the east end near the waterfront, the textile factories in the south and west parts of the city, and the lighter types of manufacturing near the center.

FARM-FOREST-RECREATION ECONOMY OF THE LAKE STATES

BY GEORGE S. WEHRWEIN

Aside from minerals, timber was the original resource of the cut-over region of the three Lake States which embraces an area of 57 million acres and now supports a population of 1½ million people, many of whom are in distress. By 1900 the effects of a migrating industry became visible in abandoned towns and tax-delinquent land. However, in the agricultural expansion following 1900 these troubles vanished, and it was hoped that "farms would follow stumps." Roads, schools and local governments were provided for the expected "dairy empire." Forests had only a residual place in this scheme, but the use of land for private recreation had made a substantial beginning. In 1920 agriculture collapsed and with it the hopes of the region for a dominant agricultural use of land. Severe tax delinquency, abandoned farms, and loss of population indicated that a readjustment of land uses was necessary. Agriculture can expect to absorb only about 18 million acres of land. Private recreation uses land sparingly; the most extensive use for the cut-over region will be forests, with public recreation in forests and parks probably third in rank. The three land uses are not separate but complementary. Because of the long time required to get land into forests, the period of adjustment is not without its difficulties. Planning is necessary, and the Lake States offer some splendid examples in this field.

WISCONSIN'S LAND USE PROBLEMS

BY A. R. WHITSON

Few States have so great a variety of radically different soils, types of topography, and other factors affecting land use as has Wisconsin. About 20 per cent of the area is rough and seriously affected by erosion; 20 per cent is so sandy that the soils are of low fertility and water-holding capacity; 30 per cent is of granitic glacial drift, the soil and subsoil of which are acid, and much of which is rough and stony; and 30 per cent is of limestone drift of excellent agricultural quality, but one-fifth of this area is marsh.

About three-fifths of the area of the State is in farms, including all the limestone drift, the rough southwestern region, one-fourth of the sandy area, and one-fourth of the crystalline rock glacial drift.

There are 6,000,000 acres of grade A (excellent), 9,500,000 of grade B (fair), 7,600,000 of grade C (poor), and 12,000,000 of grade D (marginal and nonagricultural) lands. This means that less than half the acreage can be classed as productive agricultural land.

Essentially all the good agricultural land is in farms and is improved land, but there are scattered areas of undeveloped good land in the north. Low prices received for agricultural products mean that only developed farms on good land yield a reasonably good standard of living. Expenditures for improving new land, especially that of low quality, are prohibitive.

While livestock and livestock products return 86 per cent of Wisconsin farm income, other regions with longer pasture season may in time produce these products more economically than Wisconsin.

Potatoes and canning peas are the two special crops in which the State has ranked highest, but the hot periods during the growing season make these crops liable to serious injury. In fact, there are few if any special crops of importance in the growth of which Wisconsin has any marked advantages.

PHYSIOGRAPHIC INFLUENCES AFFECTING THE RECOVERY OF METEORITES

BY BEN HUR WILSON

Although meteorites have been studied seriously for nearly 150 years, they have, to date, raised more problems than they have solved. One of these problems concerns their apparent unequal distribution. For example, Illinois is represented by only two falls, while States no larger and far less populous, to the south and west, present several times as many falls and recoveries. It is believed that this inequality may be accounted for, at least in part, by the differences in physiography of the regions involved.

LAND UTILIZATION: YESTERDAY, TODAY, AND TOMORROW

BY LOUIS A. WOLFANGER

Kaleidoscopic changes in land utilization characterize man's "conquest" of the earth.

Changes of a secondary order have been diverse, striking, and not infrequently repetitive. Varying in place and time land utilization has been carried from a simple pioneer-like or exploitative type, in which actual use consisted of harvesting nature's "crop" of animal or plant character, to highly complex régimes, then back again to utilities of simpler levels. The pageants of the Oriental Lowlands, the Mediterranean Plains, and the Central American Lowlands are merely larger-scaled illustrations of the many local communities whose history will never be written.

Major changes, taking the entire world into consideration, have not been numerous until the last few centuries, particularly if the criteria be such factors as the relative areas involved, major factors of location, and variety of resources and tools employed. Thus for centuries men clung to the lake and sea shores of the world, utilizing the land in the more immediate borders only, and gleaning therefrom all that life gave them.

The nineteenth century witnessed profound changes in these relationships. It saw men freed from the waterfront and carried into the continents, with herculean changes in land use. New types, new patterns, and new outlines of land use were defined.

The twentieth century will be marked by adjustments to these new horizons. New relationships to the sea, to associated lands, and to the lands of the world as a whole, are in process of evolution. A host of new tools, physical and social, are being forged to assist in this adjustment.

CONTRIBUTIONS TO CORRELATIONS OF SILURIAN SYSTEM IN NORTHEASTERN ILLINOIS THROUGH STUDY OF INSOLUBLE RESIDUES*

BY L. E. WORKMAN

The various stratigraphic units of the Silurian system in northeastern Illinois may be identified by the proportions and the characteristics of their insoluble residues. Samples of beds at intervals of a few inches to one foot have been obtained at numerous quarries and other outcrops, and their insoluble residue contents have been plotted to scale. The data thus obtained have been satisfactorily applied to studies of well cuttings. The residue contents of the various units are so characteristic that (1) The stratigraphic position of any outcrop can be determined within a few feet; (2) formational boundaries can be identified in well cuttings, and (3) new information on the sedimentary history of Silurian times in this area is revealed.

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